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VOL. CXVIII.—No. 3055.] *LONDON: FRIDAY, JULY 18, 1924.* [*Registered at the General Post Office as a Newspaper*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd.,
ROCHESTER. 1869
Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 36.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

Penningtons, University TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

See's Patent Hydro-Pneumatic **Ash Ejector**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS. Od 3382
Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopsgate, E.C. 3.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

Spencer-Hopwood & Kirke PATENT BOILERS. *See page 71, July 11.* 1994
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1943

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FELLOWS BROS., LTD., CRADLEY HEATH, STAFFS. 9168

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DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

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HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED
Duckham's Patent Suspended
WEIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 16. 1715

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GEORGE RUSSELL & CO., LTD., Motherwell. 1867

Telegrams:—"Cylinders," Birmingham.
Weldless-Steel Tubes
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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

For Your Repairs or any
SPECIAL MACHINERY, try THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 2213

The Mitchell Conveyor and
TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
Atlantic House, 45-50, Holborn Viaduct, London, E.C. 1.
Telegrams: "Micontraco, Cent, London." Telephone: Holborn 2822. 1713

Dredging Plant—
For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
ARTHUR R. BROWN, 54, New Broad Street, London, E.C.2. Telephone: London Wall 3418. 1814

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Regent Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD., REGENT WORKS, WAKEFIELD. 2018

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisements, pages 35 and 59.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROW'S PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd,
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 27. 1872

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1828

Machinery, Plant, &c.

For Sale, cheap, to save second removal, Six very good, second-hand, single-ended, three-furnace, MARINE BOILERS, about 13 ft. diameter by 10 ft. long, reinsurable at 180 lbs. working pressure.

NEARLY NEW STEEL LANCASHIRE BOILER, 30 ft. by 9 ft., reinsurable at 100 lbs. steam working pressure, complete with steam and furnace fittings.

FIVE LANCASHIRE BOILERS, 30 ft. by 7 ft. 6 in., now insured at 150 lbs. pressure.

FOUR CIRCULAR TANKS, 13 ft. by 6 ft. diameter by ½ in. plates, fitted with internal stirring gear.

Powerful DOUBLE GEARED BORING MACHINE, by J. Hetherington & Sons, spindle 6 in. diameter, with tapping motion, table 10 ft. 6 in. by 10 ft. 6 in.

New 20 in. DUPLEX BORING AND TURNING MILL, by G. Wilkinson & Sons, swivel slides and gear box drive, will swing in gap 22 in.

TREBLE GEARED BORING AND FACING LATHE, by Ward, Haggas & Smith, 3 ft. 6 in. centres, T slotted faceplate, 6 ft. diameter, swing about 7 ft. 9 in. diameter.

UNIVERSAL PLANO MILLING MACHINE, with two vertical and one horizontal spindle, by Kendall & Gent, Ltd., width between uprights, 4 ft. 6 in.

One 10-ton "WILSON" LOCO. STEAM CRANE, with 25 ft. jib; 4 ft. 8½ in. and 7 ft. 3 in. gauges; suitable 90 lbs. pressure.

One 5-ton "RANSOME & RAPIER" LOCO. STEAM CRANE, with 40 ft. 6 in. Jib; 4 ft. 8½ in. gauge; all complete, just overhauled, ready for work.

Several 3-ton LOCO. STEAM CRANES, by Smith, Jessop and Applebys, Booths, etc.; 4 ft. 8½ in. gauge; just overhauled, ready for despatch and work.

Thos. W. Ward, Ltd.,
ALBION WORKS, SHEFFIELD. 1726
Palace of Engineering, Wembley, Stand 189. Bay 23-24. Avenue 1-2.

Important.—For Immediate SALE AT LOW PRICES.
One Superior 400 Kw. Howden - Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure.
One High-Class Horizontal Side - by - Side COMPOUND CORLISS ENGINE, 200 I.H.P. at 80 r.p.m., belt flywheel 12 ft. diameter by 2 ft. 6½ in. on face, very suitable for export, for driving factory, sawmill, etc.
One Powerful Set COMPOUND HORIZONTAL HYDRAULIC PUMPING ENGINES, by Sir Wm. Arrol & Co., capacity 200 gallons per minute.
Two Steamdriven CENTRIFUGAL PUMPS, by Drysdale, capacity 1250 and 1390 gallons per minute.
In new condition and all seen here at Glasgow.
JOHN H. RIDDELL LTD.,
40, St. Enoch Square, Glasgow. 2191

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 2277

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1316
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 58, July 11. 2402

For Sale from Stock.
50 HP. Loco type BOILER, by Ruston Proctor, 140 lbs. W.P.
30 HP. Loco type BOILER, by Ruston Proctor, 100 lbs. W.P.
12 HP. Loco type BOILER, by Ruston Proctor, 100 lbs. W.P.
6 HP. Loco type BOILER, by Marshall, Sons & Co., 120 lbs. W.P.
Vertical Cross Tube BOILER, 11 ft. by 4 ft. for 100 lbs. W.P.
Apply:—
P. BAKER & CO., LTD., Engineers, East Moors, Cardiff. F 224

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2000

HEAT INSULATION.
CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, July 4.

Diesel Engines, 300, 530, 800,
1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
HICK DIESEL OIL ENGINES, LTD., 70, Queen Street, E.C. 4. 2043

WAYGOOD-OTIS LIFTS 2130
54 & 55, FETTER LANE, LONDON, E.C.4, 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 66, July 4.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

University College of SWANSEA.

An EXAMINATION for the South Wales Institute of Engineers' SCHOLARSHIP in ENGINEERING, of the value of £70 per annum, tenable for three years, will be held at the College, on September 8th, 1924, and following days.
Further information and prospectuses may be obtained from the undersigned.
EDWIN DREW, Registrar.
Singleton Park,
Swansea. F 361

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E.,London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 55, SOUTH JOHN STREET, LIVERPOOL. 1963

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2282

Engineering Drawing.—

Special Postal Course in Engineering Drawing. Enrol now. Fee Three Guineas for the complete course. Also day tuition in Office by qualified teacher.—PERCY PITMAN, M.I.Mech.E., (nephew of the late Sir Isaac Pitman), 26, Victoria Street, London, S.W.1. 2297

TENDERS.

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

1. POINT RODDING.
2. MILD STEEL BUFFERS for railway carriages.
3. MOTOR FIRE ENGINE, 250 gallons per minute.

Tenders due on the 29th July, 1924, for Nos. 1 and 2, and on the 6th August, 1924, for No. 3.
Tender forms obtainable from above. F 373

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of:—

1. FOUNDRY COKE.
2. WORKSHOP for FEROC and KALLAYI BRIDGES.
3. STRUCTURAL STEELWORK (Underframe Shop).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tenders for Foundry Coke," or as case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 1st August, 1924, in respect of Specifications Nos. 1 and 2, and the 19th September, 1924, in respect of Specification No. 3.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of:—
5s. for each copy of Specifications Nos. 1 & 2.
£1 for each copy of Specification No. 3.
Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.
A. MUIRHEAD,
Managing Director.
15th July, 1924.
91, Petty France, S.W.1. F 359

DUBLIN UNITED TRAMWAYS COMPANY, (1896) LIMITED.

RINGSEND POWER STATION.

The Dublin United Tramways Co. (1896) Ltd., are prepared to receive

Tenders for

TURBO-GENERATOR and CONDENSING PLANT.
Copies of Specification with Form of Tender General Conditions and Drawing can be obtained from the Consulting Engineer, Mr. C. H. WORDINGHAM, C.B.E., M.Inst.C.E., M.Inst.E.E., at 7, Victoria Street, Westminster, S.W.1.
A deposit of Three Guineas is required, which will be returnable, provided that a *bona fide* Tender be submitted and not withdrawn. Duplicate Specifications will be supplied on payment of One Guinea per copy, which sums are not returnable. All cheques to be made payable to the Consulting Engineer.
Tenders, enclosed in an envelope sealed with wax and clearly endorsed "Tender for Generating Plant," must be addressed to the undersigned at the offices of the Company at 59, Upper Sackville Street, Dublin, and be delivered not later than Noon, on Friday, August 8th, 1924.
The Company does not bind itself to accept the lowest or any Tender.
JOSEPH MOONEY, J.P.,
Chairman of Directors,
Dublin United Tramways Co., (1896) Ltd.,
59, Upper Sackville Street,
Dublin. F 350

Fire Staircase

(IRON)
FOR SALE.
Inspection invited at
110, Grange Road, Bermondsey, S.E.
Offers to be addressed to
TOWN CLERK,
Town Hall,
Bermondsey, S.E.16.
not later than 31st July, 1924. F 348

ELECTRICALLY DRIVEN PUMP.

ONE—Two stage Centrifugal Pump, 12 in. suction and delivery, capable of discharging 3500 gallons of water per minute against a head of 165 ft. 0 in.
The Pump is mounted on same bedplate with, and direct coupled to:—
ONE—260 B H P. 440 volt, three phase, 50 cycles, Slip Ring Induction Motor.
A Motor starter and oil immersed controller is provided.
The whole set is made by Messrs. Mather and Platt of Manchester.
Overall dimensions 13 ft. long by 3 ft. 6 in. wide by 4 ft. 6 in. high.
The following fittings are included:—
One Vacuum gauge, one pressure gauge, one 12 in. suction bend, foot valve, and strainer, and a certain length of delivery pipe.

Offers for the Purchase of

this PLANT are Invited by GEORGE COHEN & ARMSTRONG DISPOSAL CORPORATION, Abbey House, 2, Victoria Street, S.W.1.
Telephone Victoria 8040. F 274
Telegrams "Cohstrong Sowest."
From whom permits to view can be obtained.

COUNTY OF LONDON.

BELL WHARF OUTLET, SHADWELL.

The London County Council invites

Tenders for the Construction

of a 4 ft. diameter SEWER in Brick and Concrete, of a total length of about 200 feet, with Weir Chamber and Tumbling Bay, in the Metropolitan Borough of Stepney, in the Administrative County of London.
Persons desiring to submit Tenders may obtain the Drawing, Specification, Form of Tender, etc., on application, on or after Monday, 7th July, to the Chief Engineer at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £5, by cheque or draft to the order of the London County Council. This amount shall be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained upon personal application, and the contract documents may be inspected at the Old County Hall before the payment of the fee.
No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 28th July, 1924, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
JAMES BIRD, F 375
Clerk of the London County Council.

IN THE HIGH COURT OF JUSTICE (Companies Winding Up).

To be Offered For Sale by

TENDER, pursuant to a Order of the Registrar Companies (Winding Up) made in the matter of ALLEN & SIMMONDS (READING), LTD., Branch Nominees Ltd., v. Allen & Simmonds (Reading), Ltd., 1923, A. No. 2686, either in One Lot as a Going Concern, or in the following Lots:—
LOT 1.
(A) A FREEHOLD GARAGE, SHOWROOMS AND OFFICES situate in the centre of READING, with frontages to Friar Street and Station Road, and containing an area of about 23,000 square feet, together with the Assets and the Business carried on on such premises, and the whole of the Share Capital and Debentures in Great Western Motors Ltd.
(B) A block of TEN FREEHOLD COTTAGES adjoining the above.
(C) A FREEHOLD FACTORY at Vastern Road, READING, with Modern Buildings thereon, covering an area of about 14,500 square feet, at present let as a Motor Body Building Works, in connection with the aforesaid business.
LOT 2.
(A) A LEASEHOLD ENGINEERING WORKS, at READING containing a total floor space of about, 27,000 square feet, held for an unexpired term of 67 years at Ground Rents amounting to £77 6s. per annum. These Works are equipped with high-class ENGINEERS' MACHINE TOOLS for the manufacture of Piston Rings and other Specialities of the Company.
(B) THIRTY LEASEHOLD COTTAGES and a RESIDENCE adjoining held for a similar period at nominal ground rents.
(C) LEASEHOLD PREMISES suitable for GARAGES, situate No. 107, Caversham Road, READING, held for an unexpired term of 61 years.
(D) A FREEHOLD PROPERTY on the THAMES, at CAVERSHAM, adjoining the Bridge, formerly a Club, but now let off in self-contained Flats.
(E) A FREEHOLD HOUSE, No. 18, King's Meadow Road, READING.
(F) THE GOODWILL OF THE BUSINESS of ALLEN & SIMMONDS (READING), LTD., as a Going Concern, and LETTERS PATENT for Improvements in the manufacture of Piston Rings, etc.
LOT 3.
3,000 £1 fully-paid Shares, Great Western Hotel (Reading), Ltd.
25 £1 fully-paid Deferred Ordinary Shares, and
5,500 £1 fully-paid Participating Preferred Ordinary Shares in the Reading Foundry Co., Ltd.
Tenders, which must be on the form contained in the Particulars, are to be sent to the Registrar, Companies (Winding Up), Room 48, Bankruptcy Buildings, Carey Street, W.C.1, and marked "Tender re Allen & Simmonds (Reading), Ltd.," and delivered under seal by TWELVE NOON, on or before SATURDAY, 19th July, 1924. Particulars, with Plan, Form of Tender and Conditions of Sale, may be had of Messrs. W. B. PEAT & CO., Chartered Accountants, 11, Ironmonger Lane, London, E.C.2, Messrs. WILDE, WIGSTON & SAPTE, Solicitors, 21, College Hill, London, E.C.4; and of Messrs. PEACOCK & GODDARD, of 3, South Square, Gray's Inn, London, W.C.1. F 32

To Lathe Makers, etc.

MANUFACTURERS, Capable and DESIROUS of UNDERTAKING the PRODUCTION of PATENT MACHINERY to the extent of approx. £40,000 p.a., are requested to
Address, F 371, Offices of ENGINEERING.
Long-term Contract.
Give rough details of plant available for this work.

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders as under:—

Up to Noon, on Wednesday, 30th July, for the Supply of:—
1.—LAMINATED and ELLIPTICAL SPRINGS.
2.—HELICAL and VOLUTE SPRINGS.
3.—CRANK and STRAIGHT AXLES for Locomotives,
and up to Noon on 31st July for the Supply of:—
4.—WHEELS and AXLES for Carriages.
Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each for Nos. 1, 2 and 4, and 10s. each for No. 3 (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W.1.
16th July, 1924. F 351

BELFAST CORPORATION.

ELECTRICITY DEPARTMENT.

PLANT FOR SALE.

The Electricity Committee of the Belfast Corporation

Offer for Sale the following

PLANT:—
One Triple Expansion Bellies & Morcom Engine, direct coupled to a Mather & Platt 6 pole dynamo, 440/550 volts, with wheeler condenser auxiliaries—output 400 Kw.
One Triple Expansion Combe Barbour Engine, direct coupled to a Johnston & Philips 7 pole dynamo, 440/550 volts, with wheeler condenser auxiliaries—output 400 Kw.
Six Babcock & Wilcox Water Tube Boilers, fitted with superheaters, mechanical C.G. stokers and all necessary fittings for 200 lbs. working pressure. Evaporation 13,500 lbs. per hour.
Steam pipes, water pipes, platforms, etc.
Eight steel Coal Bunkers and 5 Steel Water Tanks.
One Edgar Allen Bucket Coal Conveyor, about 420 feet long, capacity 40 tons per hour.
One 10 HP. Mather & Platt D.C. motor.
One Steam Heater and necessary pipes.
One Hayward-Tyler Electrically-driven Plunger Pump, connected to 30 HP. motor, capacity 4000 gallons per hour.
Further particulars and conditions of sale may be obtained from Mr. JOHNSTONE WRIGHT, City Electrical Engineer and Manager, East Bridge Street, Belfast, where the above plant may be seen.
Tenders endorsed "Plant for Sale" should be lodged in my office, not later than Ten a.m. on Monday, 11th August.
The Council do not bind themselves to accept the highest or any Tender.
An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.
R. MEYER, F 362
Town Clerk.

SLIGO, IRISH FREE STATE.

THE SLIGO LIGHTING AND ELECTRIC POWER COMPANY.

Tenders are Hereby Invited

for the SUPPLY, DELIVERY and ERECTION of ELECTRIC LIGHTING and POWER EQUIPMENT, as follows:—

SECTIONS.—A. 1.—Buildings, Steelwork, etc., and Foundations.
" A. 2.—Overhead Travelling Crane.
" B. 1.—Suction Gas Producer.
" B. 2.—Gas Engines.
" B. 2a.—Water Cooler Apparatus.
" C. 1.—Alternators.
" C. 2.—Control Switchgear, Cables, and
" C. 3—Station Wiring.
" D. 1.—Main Feeders and Distributing Mains, etc.
" D. 2.—Public Lighting.
" D. 3.—Quay Lighting.

NOTE.—Meters, Installations, Wiring, Metal Tubing, Motors, Fittings, Lamps, Accessories, etc., form the subject of separate Specification.
Specification Sections, with General Conditions and Forms of Tender can be obtained from the Consulting Engineer on receipt of Two Guineas deposit per section—each deposit being returnable only after the receipt of a *bona fide* Tender, attached together with the returned Specification, Drawings and General Conditions and the signing of contracts by successful Tenderer.
Extra copies at One Guinea, but equally returnable.
The Sligo Electric Light & Power Company do not bind themselves to accept the lowest or any Tender and reserve the right to sub-divide the work into sub-section Contracts.
Also, the Company will not be held responsible for expenses or losses incurred by Tenderers in preparation of Tenders.
Tender forms properly addressed and accompanied by returned Specification, Drawings and General Conditions to be sealed and addressed, marked "Tender for Sligo Electricity Supply, Section ( )," and delivered not later than Noon, WEDNESDAY, July 30th, 1924, to the Company's Consulting Engineer.
J. C. ELVY, A.M.I.E.E.,
Chartered Electrical Engineer,
12, Tavistock Street,
Strand, W.C. 2.
July 14th, 1924. F 357

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven

a.m. on Thursday, 31st July, 1924, for the SUPPLY of VALVES.
Forms of Tender, etc., may be obtained on application to the CONTROLLER OF SUPPLIES, H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W.1. F 369

HONG KONG WATERWORKS.

It is hereby notified that

Sealed Tenders in Triplicate,

which should be clearly marked "Shing Mun Scheme—First Section—Tender for North and South Tunnels, South Conduit, and Contingent Works," will be received at the Colonial Secretary's Office, Hong Kong, until Monday, the 8th day of September, 1924.
The Work consists of the DRIVING and necessary LINING of TWO TUNNELS, approximately 2160 ft. and 4080 ft. in length, through the Smugglers' Ridge and Golden Hill respectively; the CONSTRUCTION of an OPEN CONDUIT, approximately 2000 ft. in length, and Contingent Works.
Drawings, Conditions of Contract, Specification, Bills of Quantities, Schedule of Prices, Form of Tender, Articles of Agreement, etc., can be inspected at the Office of THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, but spare copies of the above documents are not available here, and Tenders will only be received in Hong Kong. Contractors must tender through substantial local agents, who will be required to guarantee their *bona fide*, and, in the event of a successful tender, must have power to sign a contract without delay. F 360

G. H.

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PROCEEDINGS OF THE FIRST WORLD POWER CONFERENCE.—III.

CONTINUING our reports of the meetings of this Conference, and following the order in which the proceedings of the various sections were taken, we begin this week with the meeting of Section L, dealing with "Illumination," which was held on the afternoon of the 4th inst. From that point we, this week, carry our account of the meetings up to the afternoon meeting of Tuesday, the 8th inst. We will hope to complete our account of the whole proceedings in our next issue.

SECTION L.—ILLUMINATION.

This Section met on the afternoon of Friday the 4th inst., under the presidency of Dr. Alexander Russell, to discuss three papers. A fourth contribution on the "Modern Construction of Electric Incandescent Lamps," by Dr. Halbertsma (Holland), was not in print, and Dr. Halbertsma was not present. The presentation of the papers did not occupy more than a few minutes.

In the first paper on "International Co-ordination in Illumination," Mr. J. W. T. Walsh, of the National Physical Laboratory, General Secretary of the International Commission on Illumination, outlined the history, constitution and work of this Commission on standardisation, photometric definitions (which were only given in French in the paper), lighting legislation and automobile headlights, and referred to the future. International agreement, he pointed out, was of slow growth, though essential for proper industrial development. The Commission would meet in Geneva at the end of this month; the president was Mr. E. P. Hyde, of Washington, the Hon. Treasurer, Dr. C. C. Paterson, Chief of the General Electric Company Research Laboratories at Wembley, and the Central Bureau was the National Physical Laboratory.

Mr. Leon Gaster followed with a paper on "The National and International Aspects of Illuminating Engineering," emphasising the importance of adequate and appropriate illumination from the hygienic and the industrial efficiency standpoints.

The third paper was a report on "Progress in Electrical Illumination," compiled by Mr. C. W. Sully on behalf of the Electric Lamp Manufacturers' Association of Great Britain. The report dealt with the subject in an exhaustive way from the practical rather than the scientific point of view, discussing the evolution of the electric lamp, economics, principles of illumination, application to fittings, to the house, office, shop, factory, to street lighting, to railways and transport services, and to advertising and flood lighting. Special sections concerned anti-glare lamps, daylight lamps and projectors, and possibilities of expansion.

Mr. Sully's report was so thorough that one speaker after another declared himself unable to discuss it. Dr. Sharp, Chief of the New York Electric Testing Laboratories, first called upon, expressed his surprise that only four of the hundreds of papers before the Conference dealt with illumination, considering that half of the power stations' output went into illumination. The level of the illumination supplied should certainly be raised; to attain that the public wanted education—more over here than in America, as was generally admitted; plenty of light was not a spendthrift luxury. The 3 ft. candle and 5 ft. candle, mentioned by Mr. Sully as recommended by the Commission on Factory Lighting, did not go sufficiently far. Mr. C. C. Paterson regretted that the International Commission had not had the general support of manufacturers—a statement which was resented by others who thought that the Commission was too much given to defining, although Mr. Walsh mentioned that the Commission had a broad programme and would also deal with the lighting of highways, Mr. Paterson also pleaded for cheaper electric power, especially as regards domestic lighting. Mr. Dow was not in favour of prosecuting people for supplying inefficient light; legislation should be broad and tolerant. Mr. Good suggested that electricians might first put their own houses in order as regards efficient lighting. Mr. Buckle dwelt upon the tremendous difference between the intensities of daylight and artificial light. Several speakers concurred that much shop window lighting was glaring and bad. The discussion took a very general line and some of the references to the inertia of the public rather recalled the early days of electric lighting.

SECTION F.—AUXILIARY POWER SOURCES.

Under the chairmanship of Mr. T. C. Thomsen the meeting of this section was held on the afternoon of Friday, July 4, when consideration was given to a discussion of those sources of power not receiving treatment under any of the other sections of the Conference. In his introductory remarks, the chairman pointed out the extent of our dependence on the sun for many of our power resources and defined others not so dependant on that luminary. Between the full command of atomic energy and our present knowledge lay a large gap, and the papers read were attempts to improve on the records of the past, in developing other supplies of energy.

The first paper read was that by Sir Charles H. Bedford, on "Alcohol as a Source of Power." In it he stated that the enormous development of the use of the internal combustion engine, and the consequent demand for petrol as a fuel, was, of course, one of the outstanding features of present-day civilisation. The world was faced with a very serious problem as regards future supplies of fuel for internal combustion engines. Nobody who had first-hand knowledge of the position, as regards world supplies of oil, could escape the conclusion that we were within sight of a very definite and progressive shortage of supply which must be made up from some, preferably non-mineral, source. He concluded alcohol was the hope of the future, being already used in the form of mixtures with benzol, petrol, ether, &c., in various parts of the world. It was quite suitable for all purposes for which petrol was used. Alcohol was being produced from starchy or sugary materials at present, but to meet the large quantities required for fuel purposes rapidly expansible annual crops of sugar-cane, maize, sweet potato and cassava would be of assistance. The main hope, however, lay in obtaining the spirit from waste materials such as cereal straws, sawdust, waste wood, grasses and cellulosic waste products. Tropical production was essential, of course, as also manufacture alongside these supplies. No known and accepted manufacturing process existed at present, but the Prodor and Goldschmidt concentrated acid methods for cellulose conversion into sugar, and thence into alcohol, were being developed. Sir Charles suggested the formation of a governmental body, empowered to issue handsome prizes to original workers for their accomplishments in connection with the synthesis of alcohol. His standpoint was that the Government offer to the inventor should be a better one than any private firm could offer.

The Chairman then introduced Professor E. Schou, who read a paper entitled "Calculations Regarding Wind-power based on Meteorological Data." He stated that from the data he had gathered from the few stations available for the study of wind power in Denmark, together with existing theoretical work, he had managed to deduce a law for the energy produced from a windmill. Recent tests had demonstrated that the energy produced could be considered as a linear function of the velocity of the wind with the usual intensities obtaining. Let E be the effect of the windmill measured in kilowatts and v the wind velocity in metres per second. Further, let v_0 be the minimum wind velocity at which the mill could give of energy and v_1 the highest velocity which increased the effect of it. If the velocity of the winds exceeded v_1, the effect of the mill remained constant. The results of the tests were as follows:—

$$\begin{aligned} v &\leqq v_0 && \mathrm{E} = o \\ v_0 &\gtrless v \leqq v_1 && \mathrm{E} = k\,(v - v_0) \\ v &\leqq v_1 && \mathrm{E} = k\,(v_1 - v) \end{aligned}$$

K was a constant depending on the size and design of the mill and perhaps the place where the mill was erected. A curve could be plotted and showed a straight line law. Here it was convenient to assume that the windmill at any moment would give off all the energy which it could develop. Under this assumption the energy A produced could be expressed by the formula $A = K H$, where H depended on the wind velocity only and its variations within the time under consideration. The speaker's object was to show how H could be found. This was accomplished by means of the frequency curves of the wind. v was plotted as ordinate and the abscissa chosen as that fractional part of the 8,760 hours of the year in which the wind velocity within the time under consideration was equal to or larger than the mean velocity of the wind per second. Thus if S were the area of the curve, in proper units, which was limited by the lines $v = v_0$ and $v = v_1$, and further by the curve itself and the axis of ordinates, then $H = 8{,}760\ S$. It was possible in this way to calculate the amount of energy which could be developed in one year or in a given month, but it was also possible to calculate the amount of energy which could be developed in a year at a certain station by, say, east winds. In this case it was only necessary to draw the "frequency" curve H for east winds and otherwise proceed as before. The calculation of H was thus based on the frequency curves at the various stations, and these were determined by means of observations of the velocity and the direction of the wind. In Denmark such data were supplied by the Copenhagen Meteorological Institute. The paper contained schedules giving the characteristics of various stations.

The next paper was that read by Mr. R. J. Jensen, the Chief engineer of the Copenhagen Electric power-station, and had for its title "Modern Plants for Wind Electric Power Stations." Mr. Jensen said that the first essential of such a plant was that the maximum power developed should be utilised fully by the existing distribution network. In direct-current plants the generator could be either a special type of compound machine the capacity of which was adapted as closely as possible to the features of the mill, or a special system devised by himself. This was a shunt machine employed as generator with its field magnets wound in a special manner and with a speed regulation of 1 : 2 (*e.g.*, from 500 to 1,000 revolutions). The regulation for the speed of the generator was affected by means of a special relay which controlled the exciting current of the machine. Reasons for this arose from the fact that to yield the maximum output it should run at a speed in direct proportion to the velocity of the wind—the same, of course, applying to the dynamo coupled to the mill. The above-mentioned relay was so constructed that it would at all times control the exciting current of the generator in such a manner that the speed of the latter would have a previously determined ratio to the energy produced by the same. When alternating currents were used it was necessary to decide on either synchronous or asynchronous generators. In the case of the

former, he drew attention to the suggestion of Professor Rung (and others) of letting the machines run permanently connected to the service network, providing dog clutches between the mill and the generator. These were constructed to permit of the dynamo running idle in periods of calm, while if the strength of the wind increased the mill was coupled to the dynamo and caused it to produce energy. Such an arrangement would, of course, cause a considerable no-load loss during calms, but at such times the machine could be allowed to act as phase-compensator on the service network; thereby corresponding advantages being derived from its presence.

Regarding asynchronous generators, there arose the question of employing a simple machine or an alternating-current commutator machine. When the latter was used it was possible to adapt the speed of the dynamo to accord with the strength of the wind, in the same way as with the direct-current arrangement described above.

When the common asynchronous generator was employed, the speaker suggested a method diagrammatically described in his paper. The generator was constructed with a short-circuited rotor mechanically coupled to a regulator arranged so that, at a given speed, a little above the synchronous one, it would close a contact between a pair of springs in series with a small auxiliary dynamo. The latter would send a current through the operating coils for the two switches which were disposed in two phase conductors from the dynamo. Thus the connection between the dynamo and the service network was only closed when the mill speed caused the original generator to act as such. Should the speed of the generator sink below synchronous, when it would draw energy from the service network, the regulator levers dropped so far that the contact was broken, and the switches would open. Should the regulator fail, the operating circuit to the switches would be broken by a reverse current relay which was arranged between the dynamo and the service network.

The final paper read was that entitled "Natural Steam-power Plant," by Prince Piero Conti. He drew attention to the interest natural steam supplies had for countries in which they existed, and he gave a detailed account of his own work in developing this source of power in the case of the Larderello earth steam emanation. Generally a by-product assisted the finance of the project, such as boric acid in this case. In 1914 the erection of a power station was begun, and it now consisted of three turbo-alternators of 2,500 kw. each, two of which normally ran, the third being a reserve. Due to the presence of sulphur, etc., it was found necessary to use natural steam as a means of producing pure steam for feeding the turbines. Evaporators similar to water-tube boilers were used for purification. This accomplished, the natural steam at 2 atmospheres pressure was used for low-pressure turbine work. These were of the reaction double-flow type running at 3,000 r.p.m. They were coupled to three-phase alternators generating current at 50 periods and 4,000 volts. He believed that there was every likelihood of development of natural steam resources, wherever found, in the future.

SECTION G.—POWER TRANSMISSION AND DISTRIBUTION.

On Monday, July 7, the meetings were resumed. At the morning meeting of Section G, general papers on Power Transmission and Distribution were read and discussed under the chairmanship of Mr. John R. Freeman, Past President of the American Society of Mechanical Engineers.

Mr. L. Kallir presented a contribution on "Modern Practice in Power Transmission and Distribution in Austria." The production of coal in Austria was, he said, only 15 per cent. of the total demand, and it was believed that at least 45 per cent. of the required coal could be replaced by hydro-electric energy. Except for the hydro-electric resources of the Danube, the difficulties of which could not be overcome in the immediate future, the main hydro-electric plants could only be successfully developed in the Alps, while the centres of population and industry were in the Eastern and North Eastern parts of the country. Only 16 per cent. of the possible two million horse-power was yet developed. In a few years a system of 100,000 volt lines would be available for power transmission and for interconnecting the large hydro-electric plants now under construction. Three pressures would then be in use for transmission in the country, 100,000, 60,000 and 20,000 volts. The standard frequency was 50 periods, but several plants existed from which single-phase and two-phase currents were transmitted with a frequence of 42-cycles, but a change over to three-phase working with a periodicity of 50 was now in progress. Nearly all lines of high voltage would be carried by iron poles of small base. In recent years the use of reinforced concrete had been considered, and in several cases concrete poles were employed. A double T-shaped cross-section with a trussed web was used. When subjected to heavy stresses such as at angles and crossings, a hollow perforated pole of square cross-section was provided. A large sub-station under construction at Vienna would be fed from the 100,000-volt line. For the station two groups of step-down transformers, each consisting of three single-phase units of 6,000 kilovolt-amperes, would reduce the pressure to 28,000 volts, the pressure of the high tension cable system of Vienna.

Mr. F. A. Smit Kleine then described the stages in the "Electrification of Holland." They had now reached the stage of having 26 power stations ranging in capacity from 3,000 kw. to 80,000 kw. The transmission pressures were 50,000 volts and 10,000 volts and the system was three-phase with a periodicity of 50. Of the cables, 90 per cent. were underground and 10 per cent. overhead. Two distribution pressures, 220 and 380 volts, were in use. The Committee of Electricity Concerns had decided that the establishment of feeding points for the 10,000 volts system 20 to 30 km. apart was reasonab y economical, They also decided that for primary voltage little was to be gained by using 100,000 volts as compared with 50,000 volts, and recommended the use of the higher value for districts with scattered load and the lower one for use in densely populated zones. As the land was very soft the erection of overhead lines presented difficulties and was costly. In locating the run of the electrical cable system, they had to consider the electrification of the railway system. On the line from the Hague to Leyden the supply was direct current at 1,500 volts. They had considered the use of single-phase alternating current but had decided that it was not so suitable.

Generally speaking there was no universal solution for the coupling of central stations. All cases had to be considered on their merits. The possible savings by coupling in the case of Holland only represented small percentages, and they were not sure that they would be realised in practice. The ideal number of stations for the country was 8 to 10, but they had actually got 26. Gradually the smaller stations would be shut down.

Canadian practice was described in a paper on "The Transmission and Distribution of Electric Power in Canada," presented by Dr. Julian C. Smith and Prof. C. V. Christie. In it they said that water power developments were situated at considerable distance from the large industrial centres, but vast transmission networks were being erected which eventually would cover the entire country. The fact that steam coal was obtainable in Canada at prices ranging from 6 to 15 dollars per short ton, depending upon the distance from the source of supply, limited the price obtained for hydro-electric power. In consequence the investment which could be used profitably in water power development and the main transmission lines was limited to about 150 dols. per kilowatt delivered. The amount of power per mile of transmission line varied considerably and had a great bearing upon the type of construction that was installed. Eighty per cent. of the conductor material used in Canada was either pure aluminium or steel reinforced aluminium. Special insulation was in use for the lines where dust was liable to collect upon the insulators. Single circuit power lines were advisable where only two circuits were used to supply an important load, and it was desirable to erect them at a distance from each other to prevent interruptions. Where heavy steel towers were used they were spaced up to 880 ft. apart. In Canada the majority of the systems had voltages of 22,000, 44,000, 66,000 and 110,000. In the future it was possible that 165,000 and 220,000 volts would be used. Alternating current generators were in operation in Canada in sizes up to 55,000 kilovolt amperes, 25 cycles and 12,000 volts on the system of the Hydro-Electric Power Commission of Ontario, and up to 40,000 kilovolt amperes, 60 cycles, 11,000 volts at Shawinigan Falls, Quebec.

Mr. John Murphy of Canada, discussed the question of safety for power transmission lines. In early days the railway companies objected to the presence of electric power lines near their systems because of possible actions on telegraph and telephone circuits. Since then the Board of Railway Commissioners had brought the parties together to obtain agreements for their mutual benefit. Rules were drawn up by the Commissioners to provide for safe mechanical construction, to ensure effective insulation at crossings. In the 18 years during which the rules had been in operation not a single failure had occurred at the approach crossings.

Mr. William Rung then presented the paper prepared by Mr. A. R. Angelo and himself on the "Transmission of Electric Power from Norway to Denmark." This contribution dealing with the technical questions involved in the importation of electric power is reprinted elsewhere in this issue. The economic and political questions involved in this new development were dealt with by Mr. S. Kloumann in a paper on "Export of Power from Norway," which we hope to reprint in a later issue. Professor F. Jacobsen, of the Technical University of Norway then discussed "The Influence of Voltage Regulation on Electricity as a Product of Quality." The supply of electricity on the parallel system, he said, presupposed from a theoretical point of view a constant voltage at the consumers terminals no matter how the consumption varied. In practice this was not entirely accomplished. Variation might be checked at the station and on the main transmission line, but changes in the drop of voltage in distributing and branch conductors and in house wiring could not be obtained at reasonable expense. The influence of variation of voltage upon the efficiency of consuming apparatus for lighting, heating and power purposes was treated, and references were made to the economic effects under different systems of charging for electricity.

Great work has been done in the development of water power by the Styrian Water Power and Electricity Company, and particulars of this were given in a paper presented on behalf of the concern. The power demand at present amounted to 100,000 kilowatts, but large increases were anticipated to take place during the period of construction, which it was estimated would amount to 15 years. The works were spread over the country. In the Enns district the Great Enns station had been planned to give, with the use of a day storage tank, an output of 136,000 kilowatts. There were also in the same district the Erzbachradmer group of plants totalling 10,000 kilowatts and the storage works on the Thalbach and Sölkbach, with a capacity of 54,000 kilowatts. In the Mur district there were four plants totalling 75,000 kilowatts, and storage works would be available at Teigitsch and Teich-Alpe. Central and Eastern Styria would have a supply from a network at 60,000 volts while Upper Styria, having great centres of consumption, would have a network at 100,000 volts. Railway feeders would be run out independent of the general supply system.

M. Diény presented the paper of M. J. Tribot Laspière on "Les Lignes Françaises de Transmission d'Energie Electrique à hautes et très hautes Tensions." The total length of the lines amounted to 8,900 kilometres, of which 5,000 kilometres were at 45,000 to 90,000 volts and the remainder at over 90,000 volts. Regional junction work had been developed on a large scale in North and East France and also in the mountainous districts. National junction lines had been erected in many regions representing 60,000 kilowatts and others with a capacity of twice that amount were under construction. Paris and the central part of France would be connected by a line extending between the capital and Eguzon. Within two years the main

line from the Pyrenees to Lille should be completed.

Other papers submitted to this section, but taken as read, related to the "Possibilities of Reducing Transmission Losses in High Tension Transmission Systems," by Professor Wm. Rung; "High Tension Transmission Lines in the Dutch East Indies," by Mr. W. Nobel; "Distribution of Electrical Energy in Germany with Special Reference to the Bayernwerk," by Mr. A. Menge; "Rapport sur la Production D'Energie Electrique en Belgique," by M. E. M. Uytborck; "Generating, Transmitting and Distributing Electricity in Catalonia," "Technical and Administrative Systems for Rural Electrification in Sweden," by Mr. Nils Ekwall; and "Description Abrégée des Usines Centrales Electriques de l'Etat en Construction," by Mr. S. Tolkatsheff (Russia).

Mr. Reginald D. Kapp said the importance of transmission costs in the economic distribution of power was not always appreciated. The cost of coal per unit was 0·25*d.* to 0·30*d.* Assuming the reasonable load factor of 30 per cent. the capital charges on 25*l.* per kilowatt would work out at the same figure as the cost of fuel. The significance of transmission in economic distribution was therefore obvious. If 10 per cent. of the fuel was saved by improved design, the use of super stations or other means, something about 2*l.* per kilowatt was all that could be spent to do it. Extension was possible to a certain extent and new customers further afield could be added. Usually in a power scheme, coal was saved and copper wasted. The whole scheme of transmission had to be considered. Many people were interested in the economies relating to rotating machinery, but few gave the attention to the cost of distribution, which it deserved.

Mr. Sibley, of California, said he noted from some of the papers that costs to the consumer were based on kilowatt years rather than kilowatt hours. In California they had one example, where pumping was carried on continuously, suited to the system of basing costs on the yearly basis. For irrigation, pumping plant totalling many thousands of horsepower was used and worked continuously. The actual irrigation working was carried on in the day time only. During the night the head of water in the small reservoirs was continuously increased, so that the available resources at the start of work in the morning were very great. Generally the charges were based on the kilowatt hours used, and the price changed according to a sliding scale.

Dr. Guido Semenza said that in Italy they had no iron, no copper and no coal, and had therefore to study questions of economy very carefully. For power line supports they used steel structures in preference to wood because of the time they lasted. They had a difficult problem in the transport of power across the Straits of Messina to Sicily. There were strong water currents, which frequently changed in direction, which would be the cause of difficulties with submarine cables. To cross with an overhead line meant the use of a span of over 4 miles. A railway tunnel in which the cables could be run was another suggestion, but they had to remember that it was an earthquake zone.

Mr. Beard spoke about rural electrification, a field in which he thought great Britain had lagged behind. Any rural system must start by tapping the high voltage lines which had to be done cheaply and securely. Isolating switches were necessary to disconnect any faulty part of the system and leave the supply to other parts unaffected. There were too many different voltages in use and the retarded growth of development of the use of electrical appliances was in part due to this.

SECTION G.—POWER STATIONS AND TRANSMISSION LINES.

On the afternoon of Monday, the 7th inst., the proceedings of section G, were resumed by the presentation of a paper on "The Transmission and Distribution of Electrical Energy," by Mr. Charles H. Merz. The basic principles, he said, were the same in the design of a transmission and distribution system as in the design of a generating station; the capital charges and operating costs must be a minimum consistent with security of supply, simplicity of operation and ease of extension. The main differences between the two were that in a transmitting and distributing system capital charges formed a much greater proportion of the total costs, and considerations of public amenity and safety required more attention. Approximate analysis showed that the capital cost of transmission and distribution was, as a rule, as much as the capital cost of the generating station, and if fuel was omitted the operating costs of transmission and distribution were as much as those of generation. The continuous increase in the size of prime movers and of the stations had resulted in lower capital charges for kilowatt installed and increased operating efficiency. The diversity of loads in an extended area had enabled plants to be run at better load factors. Individual steam plants designed for as much as 600,000 kw. and containing generators with outputs of 60,000 kw., were now under construction. This development had been justified by improved steam cycles, using higher temperatures and pressures, with interstage re-heating of the steam and interstage feed-heating. The latter permitted the use of air heaters in place of water economisers. These charges were only made possible by the extension of the transmission and distribution systems over very wide areas. The net economy was, of course, the difference between the reduced generating costs and the increased transmission costs.

The importance of capital charges had made reduction in the cost of mains the most important feature in the development of distribution systems. This was effected in two ways; by reducing the section of the conductors through the use of higher voltages and by improving the insulating materials. Underground cables were used in large towns, and to some extent in industrial districts. The practice of employing impregnated paper insulation with a lead sheath was now general, and cable developments were mainly in the improvement of methods of drying and impregnating the cables and in the compounds used. The general effect of recent investigations was to confirm increased cable ratings and to emphasise the advantages of protecting cables by steel armouring and waterproof covering and laying them direct in the ground. The advances made by British cable makers were great, and many miles of three-core 30,000-volt cable have now been in use for some time with satisfactory results. In Northumberland there were eight miles of three-core cable operating at 66,000 volts. It appeared probable that by using single-cored cables 132,000-volt circuits could be carried underground with safety and reliability. Long circuits operating at 220,000 volts with the cables overhead were now in service in California, and all over the world there were examples with pressures ranging from 75,000 to 150,000 volts. In British practice the most obvious feature was the use of wooden poles with relatively short spans.

Through the provision of forced water cooling, transformers had been increased in capacity. The mercury vapour rectifier was proving to be a rival to the rotary converter on the Continent at voltages of 500 and 600, and promised to be still more formidable at higher voltages. Outdoor types of switchgear had become standard practice for voltages above 50,000 and were widely used for lower pressures. Automatic substations were introduced to reduce attendance changes. For alternating-current installations no great difficulty was presented. The problem was not so simple, however, with stations containing rotary converters and motor generators, but it had now been solved and numerous stations were in operations. Rapid and automatic isolation of faulty mains and apparatus became increasingly important as the size of the system extended.

Other British contributions to the papers prepared for this meeting were by Professor Miles Walker, D.Sc., on "The Improvement of Power Factor," which we hope to reprint in a later issue, and Mr. A. B. Field who presented a paper on "Large Alternators." an abstract of which is given elsewhere in this issue.

Mr. W. S. Murray, U.S.A., gave a paper on "Superpower," in which he discussed the advantages to be derived in (what he termed) "diversity economy" by the interconnection of generating stations with peak loads reached at different periods of the day. The advantages of superpower were that fixed charges could be reduced by proper interconnection, with full use of diversity capacity and consequent reduction of generating reserve. Operating changes would be reduced by the selection of sites for stations beside the coal or water resources. The conditions of the Boston, Washington, and other zones were then discussed to show the significance of the proposals in the reduction of power costs. Mr. B. G. Lamme submitted a paper to the Conference on "American Power Station Electrical Equipment," which we reprint in abstract elsewhere.

Mr. O. C. Merrill said that the design of a generator of 100,000 h.p. was now possible, and transmission over an extensive area was economical. These possibilities brought us to the period of superpower. In the region between Boston and Washington, cities 450 miles apart, and extending inland from the coast about 150 miles, there was a population of 25 million people and nearly 100,000 industrial concerns. This afforded a suitable area for a superpower scheme. It was estimated that the demand in this case would reach 10,000,000 kw. by 1930. By using high-powered steam and hydro-electric stations at strategic coal and water centres, all interconnected for joint supply, it was anticipated that many millions of tons of coal would be saved each year. With transmission at 110,000 volts, or even 220,000 volts from the stations, economic transmission to local centres was possible. The combination of water power and steam power made for economic generation. Only 4 per cent. of the electric power used in the United States was generated in municipally-owned plants. The rest was produced by companies working under regulation. Electricity concerns were best managed when in private ownership.

Mr. W. Borgquist, Director of the Electrical Department, Royal Board of Waterfalls, Stockholm, presented a paper on the "Economic and Technical Organisation of Large-scale Power Distribution in Sweden." The Government, he said, at present supplied 35 per cent. of the consumption of electrical energy in Sweden, and the municipal stations supplied 15 per cent. They had, therefore, a direct influence upon power development. The majority of the more important private systems were more or less directly controlled by industrial establishments. Development was more difficult in Sweden than in most countries because it was so sparsely populated. When the two State systems in Central Sweden, the Trollhättan system in the West and the Alvkarleby-Motala in the East, expanded, the need for greater loads, reserve requirements and supplementary equipment made it desirable to interconnect them, and a 132,000-volt line was established between them in 1920. Reserve power equipment was thereby centralised and reduced below the amount necessary for the two systems. It made supplementary steam power almost superfluous during normal years, since the time difference between the seasons of minimum power supply permitted surplus water from one system to be used as supplementary power for the other. The two systems had different frequencies, the one 25 cycles and the other 50, but the obstacle was surmounted by installing at Trollhättan two double generating sets. Each of these consisted of a 25-cycle and a 50-cycle generator of 12,000 kv. ampere capacity, mounted on the same shaft and connected to a turbine of 9,000 kw. The power of the turbine could be used to give a supply to either set of bus bars and an additional 3,000 kw. could be connected from one system to the other, with one generator acting as a synchronous motor and aiding the turbine, while the other worked as a generator at a slight overload with almost unity power factor. Energy interchanges between connected systems throughout the country were regulated by special contracts having its encouragement as their purpose. The State trunk lines were projected for 132,000 volts with a possibility of increasing the tension to 220,000 volts when conditions warranted. The South Swedish Power Company adopted a voltage of 132,000 in anticipation of a future interconnection with the State lines.

In addition to the paper by Mr. Borgquist, there were five contributions from Sweden. Mr. R. Liljeblad dealt with "Recent Developments in A.C. Generators and Motor Designs." In this paper he stated that the largest water-driven

machines so far manufactured in Sweden were supplied to the Glomfjord power plant in Norway, of which the last was of 24,000 kv.-amperes capacity and generated at 15,000 volts when running at 300 r.p.m. Low head machines running at low speeds were now finding favour and presented problems quite different from those associated with high speeds. He showed the constructions adopted and details which were typical of Swedish industry. Transformer design was treated in two papers, one by Mr. K. E. Eriksson and the other by Dr. Arle Ytterberg. The largest transformers so far built in Sweden were the step-down transformers for Trollhättan and Alvkarleby. They were rated at 20,000 kw.-amperes, but were conservatively rated, and operated between 126,000 and 70,000 volts. They were provided with water cooling, as was the case with most transformers of over 1,000 kw. capacity. Dr. Ytterberg stated that in transformation plant the capital cost of the losses amounted to two or three times the price of the transformer itself. It was therefore necessary to design transformers on the basis of total cost of transformation and of losses. In Sweden the oil type of circuit breaker had followed in design on similar lines to other countries, but claims were made in a paper by Mr. K. E. Eriksson in "Modern A.C. Switchgears in Sweden" that the structural details had been greatly simplified. Explosion chambers were used regardless of the voltage when the rupturing capacity exceeded 200,000 kw. Ratio adjusters for voltages up to 33,000 were fitted, which operated step by step, either by hand or motor, and accomplished the switching over in much the same way as a cell switch for storage batteries. The resistance temporarily connected in circuit was mounted separately. For currents over 500 amperes all interruptions were made by a separate oil switch which was mechanically connected to the operating mechanism of the adjuster. Mr. Carl A. Rossander presented a paper on "Low Tension Distribution and Electric Storage."

Mr. Bernard Price, South Africa, referred to the largest undertaking of its kind in the British Empire, the Victoria Falls scheme, and detailed some of the exceptional circumstances that had to be met, such as frequent lightning storms, and the provisions made to deal with preventing their possible effects.

Mr. Summerhayes, U.S.A., thought few people outside the country appreciated the extent to which automatic sub-stations had grown in use in the United States. By their use electrical energy was supplied to street railways and for low voltage lighting, both direct and alternating current, as well as for mining. Automatic regulation was of great value in the increased stability it ensured when machines were worked in parallel.

In a paper on "Caracteristiques des Lignes à Tres Haute Tension Établies en France," M. C. Duval discussed the technical requirements for overhead high-tension lines in France and gave details of the most important cases, namely, the 120,000-volt lines at Basse Isère, the State network, the 150,000-volt lines of the Midi Railway, and also those of the Orleans Railway.

The papers submitted by Holland were: "Recent Developments in Power Station Design in the Netherlands," by Mr. J. J. L. Smits; "Some Notes on the Stability of Power Stations Working in Parallel," by Messrs. G. J. T. Bakker and J. C. van Staveren; and "Application of Squirrel Cage Induction Motors with Special Starting Characteristics," by Mr. A. Brunt.

Mr. Guido Semenza then submitted his paper on "The Continuity and Regularity of Operation of Large Electric Systems," which we reprint in abstract elsewhere. Mr. Fred A. Gaby said that in Canada they obtained 94 per cent. of their power from water resources. 600,000 h.p. was available in 10 units, each of 60,000 h.p. The application of machines of such power was actually made possible by the oil film thrust bearing. The efficiency of the turbines was 93·6 per cent. Features of the alternators were the steel slot wedges and the self-ventilating action. The flange-shafts were made of high-grade steel forgings. Lightning troubles had been practically eliminated.

Mr. E. Wilczek then dealt with "Hungarian Practice in High Speed Turbo-Alternator Design," taking as examples the machines designed by Dr. O. T. Bláthy. In the two-pole rotor machine parallel slots were used, which were milled in the barrel-formed rotor body parallel to the axis of the alternator. As an alternative to using driving flanges of non-magnetic material between the rotor body and the shafts, Dr. Bláthy designed a driving flange and shaft of one forged steel piece of a form suitable to keep the leakage flux within reasonable limits. In the four-pole rotor design the shaft and cylindrical pole bodies were of one forged steel piece and steel sleeves were slipped on to the pole bodies. Edge-wound coils in a single layer were used, and their cooling was effected by the use of a large number of ventilating holes parallel to the coil axis and bored through the whole length of each coil.

Section G.—Cables and High Voltage Direct Current Systems.

On Tuesday, the 8th inst., Section G met under the chairmanship of Dr. S. Z. de Ferranti, to consider papers on "Cables and High Voltage Direct Current Systems," but two papers held over from consideration the previous day were submitted first. Of these one on "Recent Electrical Developments in Overhead Electric Transmission in Italy," was presented by Mr. U. Del Buono. The pressure of transmission which was 70,000 to 75,000 and in a single case was 90,000 volts, had been increased to 120,000 volts to 130,000 volts. Copper was used almost universally for conductors, but aluminium conductors with steel cores were proposed for projected schemes. The lines had 3 or 6 conductors separated by distances of 4 to 5 metres.

Mr. Renzo Norsa then submitted his paper on "The Development of, and the Limits in, Parallel Operation and Interconnection of Large Electrical Systems." The basis of interconnection was the improved production and utilisation of electric current, which was obtained by a more intensive utilisation of natural energy or by economy in the cost of installation, or by gaining an increased overall efficiency or by equalising the load through a combination of services. The cost of modern interconnection for distances of hundreds of miles was considerable when taken by itself as compared with that of the generating stations.

Mr. Llewelyn B. Atkinson submitted a paper on "High Tension Cables" in which he described the steps which had led to the development in Great Britain of high voltage cables for electric power transmission, the present technical position relative to high tension cables and also the economic questions involved in their use. In his opening remarks the author referred to a cable, a specimen of which was shown, which was designed by the chairman in 1888 and put into service to carry power from Deptford to London at a pressure of 10,000 volts. The specimen was cut from a cable recently taken out, and had been in service for 35 years. It was shown through the courtesy of Mr. G. W. Partridge of the London Electric Supply Company. Similar mains made at the same time as the specimen were still in use. In the case of low and medium-pressure cables, up to, say, 11,000 volts, the problems that confronted them were:—the provision of a copper conductor sufficiently insulated to stand the pressure, and with a factor of safety allowing for such rises in pressure as might occur, without the use of special means to suppress them, and sufficiently strong mechanically to be moved about and laid in the ground or drawn into various types of conduit. The British Electrical and Allied Research Association had published the results of a research into "Permissible Current Loading of British Standard Impregnated Paper Cables," based on the assumption that for paper insulated and covered cables a maximum temperature of 65 deg. C. would be allowed. Conditions of economy had led to a desire to work at higher temperatures, and American writers had in fact urged that a temperature of 85 deg. C. was not unreasonable. The records of cable failures in American cities showed a frequency of breakdown, which was out of harmony with the outlook of British engineers and the general public. More evidence was necessary before any considerable advance in temperature could be thought advisable.

For high voltage cables, in addition to the points referred to in connection with low voltage cables, there was a limit imposed on design by the necessity of getting rid of the heat from the internal conductors. Other points of importance were the actual strength of the insulating material to withstand electric puncture and the disposing of the heat set up in the dielectric itself under the influence of high electric stresses. In most dielectric materials a considerable transient current was observed, followed by a much smaller and gradually diminishing current which, however, never became zero. The first current approximated to the true dielectric phenomena, it was a movement of electrons within the atom setting up an electric stress balancing the applied electric stress and preventing further movement. As the applied stress was increased, the movement increased until at some limit, different for each material, the forces holding the electron within the atom were overcome, a true conductive current ensued and the insulator was broken down. Such would happen in a perfect dielectric, but the smaller and permanent current was a true conductive current and the researches of S. Evershed and G. L. Addenbrook had made quite clear that this current was an electrolytic current, and that the medium was the moisture which was contained and held mechanically in the substance of the dielectric.

The requirements of flexibility necessary for a cable insulation were only satisfied by a very few materials, such as rubber, or by substances which could be put on in layers which could stretch or move individually; a further type was material like paper, which could be dried and impregnated with oils with the idea of excluding moisture. Experience showed that it was perfectly feasible to build and joint permanently three-core cables for 40,000-volt circuits, but it was clear that before much higher pressures were practicable, the effects of time on cables carrying high electric stresses must be observed. The absolute exclusion of air and avoidance of ionisation of air was essential and seemed to have been achieved, but the action was one requiring time which could not be decided at once. The future of high-pressure cables depended upon a more complete understanding of the real nature of so-called di-electric breakdown. The lessons of Evershed's and Addenbrook's researches were not yet completely assimilated. The elimination of the last trace of moisture was of great importance in cable making and when methods or substances, which permitted this were available, much higher pressures than used at present could be adopted.

M. Luigi Emanueli then presented his paper on "Electric Cables for Extra High Tensions." This was a consideration of the losses in a power cable, taking into account not only those due to the heating of the copper, but also those due to the energy dissipated in the di-electric. The first of these sources of loss, assuming that the power transmitted and the cross-section of the conductor remained constant, decreased as the square of the pressure of transmission, whilst the second increased in more or less the same ratio. There was, therefore a certain pressure of transmission for which the total energy losses was a minimum. This minimum pressure could be calculated from

$$V = \sqrt[4]{\frac{r\,\overline{V}\,\overline{A^2}}{\omega\,C\cos\phi}}$$

where ω = angular velocity, $\overline{VA}$ = number of volt-amperes, r = effective resistance of the line, taking into consideration the power losses due to eddy currents in the conductors, lead sheath, &c., for a single conductor if the system was three-phase and for a loop formed by two conductors if the system was single phase, C = effective capacity, *i.e.*, that value which, when multiplied by ω and by the voltage between each phase and earth, gave the charging current in each phase. In obtaining this expression, it was assumed that the capacity of the cable was independent of the thickness of insulating material, but the error so introduced was very small. In tests in which the temperature was kept constant at 60 deg. C., throughout the cross-section of the di-electric, the power factor at a working pressure of 60,000 volts, 42 cycles was found to be approximate 0·013. The author concluded with a consideration of the maximum tension permitted by technical considerations in actual cable construction.

Mr. E. B. Wedmore then submitted the paper on

"Loading Limits for Electric Power Cables: Some Recent Researches," prepared by Messrs. E. Fawssett, S. W. Melsom, C. Vernier and himself. Prior to this research, he said, there was a serious lack of data on the safe loading of buried cables. The problem was of immense importance to the user of cables, and the work completed was calculated to be worth 250,000*l.* per annum to the supply undertakings of Great Britain. It was considered in this work that for voltages up to 11,000 and temperatures up to 65 deg. C. in modern cables that the losses in the dielectric were negligible. Investigations were now being conducted into dielectric losses at higher voltages. The thermal resistivity of the dielectric in impregnated cables of British manufacture for voltages from 3,300 to 11,000 was about 550. That of the covering averaged about 300 and of the soil about 180. A reduction of 20 per cent. in the thermal resistivity of a dielectric reduced the temperature rise by 10 per cent. The average thermal resistivity of the coverings of a cable taken as a whole, armouring, bedding, taping and serving, was found to be about 300. A large amount of data was collected to obtain the values of actual ground temperatures for the British Isles, Australia and India. Calculations were based on 15 deg. C. after careful consideration of these results. The two factors fixing the maximum temperature at which cables could be operated were the maximum temperature which the dielectric and conductor would withstand without deterioration of electrical and mechanical properties, and the effects of differential expansion, either between the various components of the cable or between it and the ground or duct in which it was laid. The values suggested were: for armoured cables laid direct on the ground 65 deg. C., for plain lead sheathed cables in ducts, 50 deg. C., and for armoured cables drawn into ducts, 60 deg. C. It was shown that cables drawn into ducts required 5 per cent. less current to produce the same temperature rise as those in air. A three-cored lead-covered and armoured cable, with 0·15 sq. in. cross-section of conductor, as used for 20,000 volts and laid direct in the ground, if running continuously at half its rated current could then carry for an hour 20 per cent., or for two hours 13 per cent. more than the maximum permissible current for continuous rating.

In submitting their paper on "High Voltage Direct-current Generation and Distribution of Electrical Energy" the two authors, Messrs. J. S. and W. E. Highfield, both spoke. Mr. J. S. Highfield first dealt with the claims to recognition of high-voltage transmission by direct currents, and reviewed the steps made in the development. He then quoted a paper contributed by Mr. Roger T. Smith to the Institute of Transport in which a particular case of railway electrification was worked out for three-phase alternating currents and direct-current transmission at 100,000 volts. All substation buildings and machinery, except that of the power house, were dealt with in the consideration of the cost of power transmission. The figures obtained were 730,000*l.* for the three-phase alternating-current system and 355,000*l.* for a direct-current system working from a Transverter. If after transmitting direct current suitable means were available to convert it back to alternating currents for distribution, there was a substantial value in the direct-current system. There was no likelihood of a suitable high-tension direct-current generator being produced in the immediate future, so that it had to be converted from alternating current initially.

For this purpose Messrs. W. E. Highfield and J. E. Calverley—devised the Transverter, a machine which combined the functions of transforming and converting simultaneously, and at the meeting this machine was described by Mr. W. E. Highfield. This valuable and interesting development had many advantages. All windings were stationary, were not subject to mechanical stresses and were immersed in oil. The commutators being fixed were relieved of mechanical stress, and thus could be effectively insulated. The only high-tension revolving portion of the plant was the brush gear, which admitted of a perfect mechanical and electrical construction for use at high speeds. Readers of ENGINEERING are familiar with the construction and operation of the Transverter which was described very fully in a recent article (see ENGINEERING, vol. cxvii, page 563). Tests had been successfully made with the Transverter under a great variety of conditions. Taking supply from a 3-phase 2,200-volt 50-cycle circuit, direct current was obtained at 100,000 volts, and two supplies had been obtained simultaneously, the one direct current at 100,000 volts and the other 440 volts alternating current. In other tests with a direct-current supply at 3,000 to 4,000 volts, 440-volt alternating current had been obtained, or low-tension alternating current and high-tension direct current simultaneously. The Transverter had therefore performed all the functions that could be met in transmission work, and if development continued in the same satisfactory way it would soon be applicable to the actual transmission of power. We hope to reprint the paper later.

In opening the discussion on the series of papers Mr. G. L. Addenbrook said that after forty years' work they had still to own that the dielectric was the limiting factor in cable design. He then discussed the actions in a dielectric due to electrical stress, and showed how the atomic structure of the material was pulled out of shape under these actions. The root of the troubles experienced with high-tension cables was due to the presence of electrolyte, which was nearly always water. When the water was broken up it existed in the form of ions having separate charges. Water was actually pulled through the dielectric by the alternating actions. Were moisture got rid of the cable troubles would disappear.

Major A. M. Taylor said he had designed a cable on the basis of maximum potential gradient, which was exceedingly satisfactory. Looked at from that standpoint it was possible to make a cable to work with 220,000 volts supply. Mr. J. W. Lieb, a delegate from the United States, then called attention to the fact that they had failed to profit fully from the research work of early pioneers. It appeared that cables were not regarded by many people as important seats of physical actions, but as commodities in the design of which the only consideration was mere mechanical spacing. The problems involved were of the greatest importance, and could only be solved by the application of the results of experimental work. The solutions of cable problems were fundamental questions of national importance.

Mr. C. P. Sparks, referring to research work, stated that, although the cable work was started eleven years ago, not much was done until Mr. D. N. Dunlop took the matter up through his organisation. Many minds had been directed to the improvement of power-station equipment, but the questions involved in transmission and distribution had not received the attention they deserved from the general engineering public. Advances in transmission, where most of the capital of an electricity undertaking had to be expended, were the important features in the future prosperity of the electrical industry. All joint boxes should be plugged. With the breathing that took place a pumping action went on and moisture was drawn in. With the higher pressures they now contemplated, further problems relating to dielectric hysteresis would be encountered.

Mr. Dunsheath asked what were the reasons for believing that the effective capacity could be ignored in the formula for the pressure suited for a given cable enunciated by Mr. Emanueli. All cables had temperature variations which made it impossible to assume steady conditions. Mr. Blackburn asked for information on how the commutation was effected in the Transverter that it was regarded as perfect. He also sought information on the shape of the alternating-current waves in different parts of the system. A third question was the effect that variation in the power factor had on the commutation. Information would be useful on what happened when the alternating current had various amounts of lag. He asked if the development reached the stage when it was possible to design a machine to give, say, 1,000 amperes at 3,000 volts, such as might be required for traction.

Mr. S. W. Melsom said that on the question of loading limits they were indebted to Kennelly for his work, as well as to workers in Holland, France, and Germany. That work had now been carried a good step forward, but they could not help feeling that in this work men of all nationalities were colleagues. Temperature gradients varied greatly, and engineers must settle what were the conditions that were approximated to in practice, so that they might be considered in dealing with further experimental work.

Mr. Luigi Emanueli, in reply to the discussion, said that the formula referred to by Mr. Dunsheath was only submitted as a tentative way of getting a solution to the problem. It was not absolutely correct, but in the paper a graphical method was given by which accurate results could be obtained. In the appendix to the paper the values of the power factor were given which had been calculated for various cables. He had taken into accouut the variations of temperature between one part and another of the cable. The heat transmission caused by dielectric losses had also been dealt with. Actual effects verified the deduced results.

Mr. W. E. Highfield said that in the tests they had used as large a load as was possible at the time. From the designers' point of view the Transverter was very flexible. The wave forms were either sinusoidal or rectangular. The rectangular waves were caused by the salient field. The machine was absolutely compensated, and the actual compensation could be studied very easily by means of the oscillograph. As long as such waves were produced the commutation remained perfect. The power factor was completely under the control of the designer. Adjustment was possible by means of a shunt regulator on the synchronous motor, but it did not in any way affect the commutation of the machine. Designing a low-tension machine was purely a mechanical problem.

Mr. Ll. B. Atkinson said Mr. Taylor had referred to the potential gradient in a cable and spoken about the design of cables from the standpoint of the logarithm of the potential gradient. It was not the case that the conditions followed the logarithmic curve, although in some experiments results had been obtained which it was assumed by some investigators did do so. It was to be remembered that a cable usually broke down in the outer layer, which opposed all deductions from the potential gradient theory.

The chairman thanked the various speakers for the remarks they had made about the Deptford cable. Electricity supply, he said, was much too complicated to-day. In all new developments the first endeavour was to accomplish the desired results. They had then to undertake work with a view to carrying out what they required more easily and more cheaply.

GAS AND FUEL SECTION.

Several of the papers discussed by this Section on Monday, July 7, had already been brought before Section C on the previous Thursday, and were mentioned on page 37 and subsequent pages of last week's issue. Both in the morning and afternoon sessions the conference hall was fairly well filled long before Mr. Milne Watson, President of the National Gas Council of Great Britain and Ireland, opened the proceedings.

Mr. Milne Watson's introductory address was of a very general character. He remarked that the gas industry of this country now used annually 16,000,000 tons of coal and 46,000,000 gallons of oils to produce 8,000,000 tons of coke and various products; 163,000,000*l.* were invested in the industry, which had taken the lead in a co-partnership policy for the benefit of their employees. Since 1885, inclined and, later, vertical retorts had been replacing the horizontal retorts. Many valuable products had been evolved and nothing was wasted; the suggested use of naphthalenes and phenols as motor fuels was of doubtful value. The chief problems to be discussed concerned methods of gas manufacture, the supply of gas to the consumer and the relation of the gas industry to the electric and power industries.

A paper on "Illumination by Gas," by Dr. J. S. G. Thomas and Mr. D. Chandler, of the South Metropolitan Gas Company, was presented by Mr. Chandler. Murdock and other pioneers, he pointed out, had only been attracted by gas as an illuminant.

Their gas was only of one or two candles per cubic foot; the Bunsen burner came in 1855, the incandescent mantle of Auer von Welsbach in 1885; inverted gas burners and high-pressure burners promised further economies. The paper proceeded to advocate a higher standard and greater uniformity of illumination, free from glare. Exclusive reliance on artificial light was sometimes more economical and satisfactory than the provision of windows and light shafts. The presence of a little carbonic dioxide (even 0·3 per cent.) in our rooms was far less objectionable than had been believed; provided air were kept in circulation, gas was the light medium *par excellence*. The average thermal efficiency of carbonisation was 70 per cent. to 80 per cent., against 8·5 per cent. obtained in electric generating stations; illumination by gas was to be recommended on the score of efficiency, conservation and utilisation of our coal supplies.

Sir Arthur Duckham had added an illustrated appendix to his original paper on the "Use of Town Gas in Industry" in order to support his statement that there are many processes in industry in which gas immediately commends itself as an ideal fuel. In America, he stated, the gas and electricity undertakings were frequently combined; over here they were often in competition. As regards raw coal, the only cause for its use was its cheapness; but the cheapness was delusive when we considered the expense and labour of transport, the congestion it caused in traffic, and the smoke nuisance. Pulverisation converted solid fuel almost into a gaseous fuel; but the fuel should first be heat-treated for recovery of its by-products. Gas was the best known form of fuel for all purposes, the simplest in transport and application, and it reduced labour costs to a minimum. Co-ordination was essential to give us cheaper gas. Without burning raw coal, co-ordination might be secured in three ways: The gas undertaking might receive and treat the fuel and turn the residue, coke and gas, over to an electricity undertaking; the electricity undertaking might first treat the fuel and turn the gas and products over to the gas undertaking for distribution and further treatment; coke ovens might treat coal and provide coke and gas to both the undertakings. Sir Arthur urged, in conclusion, not only co-operation of the two industries, but the creation of a central body with a Government Commission; Sir Arthur referred to the Electricity Commissioners of war time in this connection.

Professor H. E. Armstrong, opening the discussion, supported this proposal, reminding of the plea he had made on the previous Thursday (in Section C) for some organisation to inform public and political opinion on these matters and for the need of Fuel Commissioners. But he criticised some of Mr. Chandler's statements; the impurities in our gas and the carbon dioxide produced were badly felt in the low, modern "bungalow" rooms. Tar was probably not indispensable for dyes, which might be made synthetically.

Mr. D. Brownlie submitted some of Sir Arthur's figures, *e.g.*, gas sold at 4·4*d.* per therm, three times the price of raw coal, to severe criticism; gas was certainly convenient, but leakage and other points should not be disregarded. Sir Dugald Clerk in turn attacked Mr. Brownlie for discussing the burning of gas under boilers; gas was the fuel for engines, and it was striking that some small producer gas installations of people who liked to make their own electricity realised the highest efficiencies tabulated. Sir Dugald deprecated too much Government control; a Government department might be very inefficient, but would continue to exist.

In presenting a paper on "Coke as Fuel for Steam Raising," Mr. E. W. L. Nicol, of the London Coke Committee, accentuated the fact that the oil supplies could not last, that coal was the basic fuel of the British Empire, and that distillation of coal could supply liquid fuel required and would yield coke which should become the chief fuel for steam raising. He recommended his "sandwich" system, in which the stoker feed-hopper was divided into two compartments delivering low grade coal and coke in super-imposed layers, the coal being uppermost; one London power station had since 1918 consumed 40,000 tons of coke annually, about half of its total fuel. Mr. Nicol also pointed out that if the 10,000 tons of coal burnt in London every day were to be pulverised, 2,000 tons of ashes would be ejected and London might slowly be buried by the ashes.

Mr. F. W. Goodenough, chairman of the British Commercial Gas Association, spoke under the title of the next paper on "Fuel Conservation and Smoke Abatement," broadly of fuel. But he said: "There is no alternative to coal as the basic fuel in this country; it is coal or nothing with us." Reviewing the three methods of coal utilisation, direct local combustion, direct combustion in central electric power stations, and distillation, he advocated the third as the most conservative, the simplest, cleanest and healthiest, most economical in cost, time and space, and as contributing most to our comfort. Gas required less space than coal in storage and in flues even in our houses; it was at least equal, if not superior, to electricity, in domestic and industrial heating, and the recovery of by-products turned the scale in favour of carbonisation. Electricity had its own great fields in power transmission and distribution. Mr. Goodenough referred at length to the Report on the Coal Gas and Electrical Supply Industries, prepared by Sir Dugald Clerk and Professors A. Smithells and J. W. Cobb some years ago.

In the discussion of the last two papers Mr. F. S. Sinnatt, of the Fuel Research Board, asked what was to become of the yearly output of 37,000,000 tons of household coal if carbonisation were to be the rule; that would have a great influence on the coal industry. He also urged the study of the constitution of coal as all important to the preparation and treatment of coal. Dr. R. Lessing supported that plea; we were in ignorance of what coal actually was, and might waste its intrinsic value by unsuitable treatment. Mr. Nicol's objection that pulverised coal spread the ashes really applied to every coal-using industry. The point was, of course, that collieries did not know how to remove the mineral constituents. Mr. Frank Jones further urged the need of purification, especially of the lower seams, before the coal reached the works.

Before closing the morning session, Mr. Milne Watson drew attention to the exhibits displayed in the conference hall by Sir Robert Hadfield, exemplifying fuel economy and the measurement of high temperatures.

The main object of the paper on "The Co-ordination of Fuel Supplies"—the first taken on Monday afternoon—by Dr. E. W. Smith, technical director of the Woodall-Duckham Companies, was to stimulate discussion on co-ordination of supplies, of management, products and efforts between all the interests involved, including collieries, gas and electricity undertakings, coke ovens and industrial and domestic users by various means; improved working at the collieries, improved conditions at coke ovens, combinations of undertakings, utilisation of the waste heat of gas, production of smokeless fuel and coke for domestic purposes, the use of high volatile and cheaper non-coking coals for gas making, and a close study of the effect of freight on the cost of energy production. The paper contained balance sheets of coal production in Great Britain, and plans of coalfields and of distillation, industrial and power centres. About 45 per cent. of the coal mined, Dr. Smith stated, was small coal, of which only 4 per cent. was washed; the average ash content was at least 10 per cent.; if that figure were reduced to 7 per cent., transport of 4,000,000 of inert material would be avoided. The average moisture content of coal was also 10 per cent. The coking coals made up 6·6 per cent. of the total; so far non-coking coal could not serve for gas making. The electrical industry required 6,800,000 tons of coal per year, including 1,000,000 tons of coke breeze; 13,300,000 tons of coal were coked; if all that coal were coked in the most efficient producer-fired ovens, $\frac{2}{3}$ of the gas requirements of the country would be available; actually 12 per cent. was available. Dr. Smith also referred to their recent experiments on reducing the coking time; they ground the coal, briquetted it with other coal or coke and with half the usual amount of pitch and carbonised at rather high temperature, obtaining a smokeless fuel in one-third the former time.

We have already noticed Dr. Lander's paper on "Low-Temperature Carbonisation." In presenting it on Monday, Dr. Lander said that the Fuel Research Board was not prejudiced for or against low-temperature carbonisation—a statement to which Mr. Frank Jones, in the chair during part of the afternoon, assented on behalf of the gas industry. One important problem was the use of coke not suitable for metallurgical furnaces and other purposes; but that did not particularly apply to low-temperature carbonisation. Extraordinary yields, certainly not realised by the Board, of ammonia and of oil, were sometimes claimed for the latter process.

In the course of the discussion Professor H. E. Armstrong again showed his coalite coke, produced from Kent coal, in an 8 in. pipe, 9 ft. long, by carbonisation for four hours at 600 deg. C. Mr. Brownlie said that several processes of low temperature carbonisation were worked by experienced companies in the United States and Germany. Dr. Zur Nedden, of the Berlin Reichskohlenamt, remarked that they had technically found several of these processes to be fairly good, but the economy was very doubtful. He was interested in Dr. Armstrong's carbonisation in four hours. The shortest period seemed to promise best, because time was a crucial economical consideration; by the use of lead baths the Ford Company, of Detroit, had, it was said, reduced the time to five minutes.

Dr. A. B. Fieldner, of the United States Bureau of Mines, who has been able to examine the Ford (Caracristi) process* in the Ford works at Walkerville, Canada (opposite Detroit), though before the plant was in operation, said that the process was mechanically beautiful and appealed to the chemist. The coal, ground and mixed, came down on a plate conveyor which floated on the lead the latter being fused by the heat of the combustion and kept at known temperature (about 1,200 deg. F.); the arrangements were convenient for studying the influence of temperature on the products, gas, coke, fuel oils, &c.; but Dr. Fieldner could not say anything about the economy of the process. Dr. Lander added that the Ford company seemed to aim at pulverised fuel, while the Fuel Board was after a solid domestic fuel. That the carbonisation should be effected in thin layers ($\frac{1}{2}$ in.) had long been understood; but such plants were bulky. Carbonisation would further be improved by blending the material so as to increase its conductivity. The blending could be effected with or without heating and binders, and at low and high pressures. They had in blending at Greenwich used no binders, little heat and low pressure, but Dr. Smith's method was interesting.

The discussion having once more reverted to pulverised fuel and ash trouble, Mr. H. W. Brooks, of the Bureau of Mines, stated that the Bureau had not yet conducted any tests, but on inquiry they had been informed by the municipalities of Milwaukee and Cleveland, where the use of pulverised fuel was most extensive, that no complaints had been made about increased deposition of ashes and dust; there had been complaints, however, he understood, about the small domestic pulverised fuel plants at Seattle, which had been mentioned in Section C. Closing this discussion, Mr. Frank Jones remarked that the gas industry had not developed in a hap-hazard way as had been suggested; they were in favour of co-ordination, but would do without Government control as much as they could. Mr. Milne Watson, resuming the chair, concurred.

Mr. Gordon Adam, of the Gas Light and Coke Company, who had taken an active part in these discussions, then presented his paper, "Liquid By-Products of Coal Carbonisation as Sources of Power," which we noticed last week.

Professor Ramsin, of Moscow, next made a long communication on the subject of the potential power of Russia. The report, which went into great detail, pointed out that coal might be estimated to represent 43 per cent. of the available power of Russia, and wood and peat almost as much. The water power utilised constituted 3·5 per cent.; the oil power 0·5 per cent. of the total. Wood and peat, being renewable, were the most important

* The process was described by V. Z. Caracristi in "Power," of May 29, 1923.

resources at present, and Russian engineers had to be very careful as to power in their designs.

In the last paper taken, Professor F. W. Burstall reviewed the evolution of the gas engine, which would ultimately, he thought, be the engine of the future if properly developed. That would require the utilisation of waste gases and improvement of gas producers and of the gas turbine. Carbon oil fuels were no solution of the problem. Cast engine cylinders would have to be abandoned; with forged steel he had gone down to wall thickness of $\frac{1}{2}$ in. The principle of the Holzwarth turbine was correct; reciprocating compressors were, however, too bulky in these turbines, and rotary compressors inefficient; but suitable devices and materials would be found, and the problem was no longer a question of ingenious invention. Sir Dugald Clerk, commenting upon the paper, did not think that Holzwarth had overcome the compression difficulty; the material difficulty was, however, being solved. A new Hadfield steel retained high strength at 900 deg. C.

Before the meeting concluded, Professor A. W. Bone made a final appeal for fundamental coal research.

SECTION E.—INTERNAL-COMBUSTION ENGINES.

The Section relating to internal-combustion engines met on Tuesday morning, July 8, under the chairmanship of Mr. Frederick B. Brown M.Sc., consulting engineer, of Montreal. The chairman, after a few introductory remarks in which he referred to the honour done him in asking him to preside and also to the position of the internal-combustion engine in Canada, called upon Mr. James Richardson to deliver his paper which formed the first item on the programme for the meeting of the section. This paper, which contains a brief survey of the development of the internal-combustion engine in this country in connection with aero engines, motor-car engines, large gas engines and land and marine oil engines, we hope to deal with at greater length in a future issue.

The next paper on the programme was one entitled "Gaseous Explosions within Closed Vessels," by Mr. R. V. Wheeler, but this, in the absence of the author, was taken as read. A paper on "The Gas Engine," by Professor F. W. Burstall, was similarly dealt with, and a paper by Dr. Ing. A. Nägel, describing the development of the Diesel engine in Germany, was then taken. Dr. Nägel, in summarising his paper, stated that the chief progress made was in connection with the better utilisation of the material so as to reduce weight and also in the application of the two-stroke cycle to large engines. Further developments had been made in connection with methods of fuel injection and in the use of fuels of low calorific value. The author mentioned that a double-acting two-stroke engine, referred to in his paper, was now under construction with a cylinder bore of 800 mm. and a piston stroke of 1,400 mm. The engine, he said, would develop 1,600 metric horse-power per cylinder at 100 r.p.m. The paper, of which an abstract is given on page 110 of this issue, also gave particulars of reducing and reversing gears for use in connection with high-speed Diesel engines.

Brief abstracts of a paper by Mr. G. Agnelli on "Internal Combustion Engines for Motor Transport and Aviation," and of one by Mr. G. F. Tosi on "Large Internal Combustion Engines," were then read by Mr. R. Norsa, of Milan. Mr. Agnelli's paper dealt with the effect of racing on the progress of motor-car engine design, as well as with the influence of the war and of taxation. It described the development of the Fiat Company and its contributions to the motor industry, described the post-war models of this firm and of other Italian manufacturers, and dealt with the progress and tendencies of the Italian motor industry as a whole. The author pointed out that the specific power of a motor-car engine had increased at the same rate as the increase in the piston velocity, so that while a maximum of 28 h.p. per litre of cylinder charge at 3,200 r.p.m. was obtainable from racing cars in 1914, about twice this power was now developed at a speed of over 5,000 r.p.m. and an average piston velocity of 20 metres per second. Another important factor in the development was the increase in the compression ratio, but the author expressed the view that the present limits of compression pressure and speed would not be greatly exceeded in the future, owing to the properties of the fuels commonly employed, and for other reasons. It was possible, however, to raise the average pressure, and therefore the specific power of the engine by supercharging, and, by this means, the Fiat Company had been able to obtain a specific power of 70 h.p. per litre of charge in the engines of racing cars. The possible applications of supercharging were dealt with in the paper, and consideration was also given to the question of substitutes for petrol, the cost of which is high in Italy.

Mr. Tosi's paper first dealt briefly with large stationary Diesel engine installations, and then referred to the use of this type of engine for the propulsion of submarines. The remainder of the paper related to the use of Diesel engines in the mercantile marine, the greater part of it being devoted to the consideration of double-acting marine Diesel engines for developing high powers. The author mentioned that Messrs. Tosi, Messrs. Beardmore, and Messrs. Richardsons, Westgarth, were developing a double-acting marine Diesel engine capable of producing more than 1,000 h.p. per cylinder, which would be the largest marine oil engine built. The engine, he added, would have sufficient power to propel a 20,000-ton vessel at a speed of 18 to 20 knots, the installation developing 20,000 brake horse-power on two shafts. The author expressed a preference for the four-stroke cycle as compared with the two-stroke cycle, and dealt briefly with the design features of the components of engines of the former type for developing high powers.

The next item on the programme was a joint contribution by Professor E. Hubendick and other authors, dealing with the development of the internal combustion engine in Sweden. The first section, of which Prof. Hubendick was the author, gave a general review of the subject, and this was followed by sections relating particularly to Diesel engines, and to hot-bulb and high-compression oil engines by Mr. K. J. E. Hesselman and Mr. G. Dellner, respectively. Two other sections, dealing with carburettor engines and gas engines, were contributed by Prof. Hubendick. Mr. Dellner's contribution is reproduced on page 105. In outlining the subject of the paper, Professor Hubendick pointed out that, owing to the plentiful supply of water power in Sweden, the development of the internal combustion engine was of less importance to that country than to others. Internal combustion engines had therefore been developed mainly for special purposes, such, for instance, as a reserve for use in hydro-electric power plants, for use in agriculture and particularly for marine propulsion. Both the Diesel and the hot-bulb engine had been very successfully applied for the latter purpose, and the improvements of these two types of engine, at the present time, were directed towards the system of solid injection. In the development of carburettor type engines, efforts were being made to utilise alcohol made from sulphite lye—a by-product of the pulp industry—since alcohol can be obtained cheaply and in large quantities from this source.

The only other paper taken at the meeting was one by Mr. P. R. Meyer entitled "Large Gas Engines in German Power Economy." In giving a *resumé* of his paper, of which an abstract is given on page 105 of this issue, Mr. Meyer remarked that it had been stated that the large gas engine was dead in the United States but it was by no means dead in Germany. Modern engines of this class, he said, were among the most reliable of prime movers, even in competition with steam engines. They were especially useful where constant running, year in and year out, was a matter of importance as, for instance, in chemical works where the working of a process often depended upon the reliable operation of the prime mover. The large gas engine, he remarked, had not only succeeded in holding its own among other prime movers, but had displaced the latter in some cases which had at first seemed to offer but little opportunity for the use of gas engines. The advances made in steam practice by using the highest pressures had been countered, in the case of the gas engine, by supercharging and waste-heat recovery. The gas turbine, although a very desirable form of prime mover, had not yet entered the field as a serious competitor. In conclusion, he remarked that it was necessary to develop the gas engine, as well as the other types of prime movers, in order to make the most efficient use of the power resources available.

The one remaining paper on the programme, by Professor C. E. Lucke, of Columbia University, New York, was taken as read, and the chairman then called upon Professor Griggs, of Saskatchewan, to open a joint discussion on the whole of the foregoing papers. Professor Griggs referred to the use of motor cars and tractors in Canada, stating that while farmers formerly preferred large tractors giving 10-15 h.p. at the draw-bar they now employed smaller machines. There was a tendency to increase the speed of ploughing which was about 2 miles per hour a few years ago but now ranged from $2\frac{3}{4}$ to $3\frac{1}{2}$ miles per hour. The speaker referred to the difficulty experienced with paraffin tractors from the paraffin finding its way into the lubricating oil in the crankcase, and also mentioned the Hvid high-compression cold-starting oil engine.

Mr. Pochobradsky who followed, spoke favourably of the possibilities of the gas turbine, stating that a new steel, recently referred to by Sir Robert Hadfield, appeared to be suitable for the construction of the blades and wheels. The steel, he understood, had a tensile strength of about 22 tons per sq. in. at 900 deg. C. and had the additional advantage that it was non-scaling. With this material it would be possible to employ higher compression pressures than would otherwise be the case, because the question of exhaust temperatures would then be of less importance. It was a mistake, the speaker added, to say that because the internal combustion turbine was not equal to the reciprocating engine in efficiency that the former was not a commercial proposition. Questions such as the price per brake horse-power, repairs, weight, durability, &c., had to be taken into consideration as well as efficiency, and if this were done, he thought a more optimistic conclusion would be reached as to the future of the internal combustion turbine. In connection with reciprocating engines, he referred to the use of high pressure steam, generated from the exhaust gases, in place of compressed air for fuel injection, and on the subject of heat stresses expressed the view that these resulted largely from the fact that designers attempted to master the forces instead of the temperatures. With regard to the question of the two-stroke cycle *versus* the four-stroke cycle, he pointed out that the average temperature per cycle was lower with the latter than with the former. For slow-speed engines, the two-stroke cycle might be just as good as the four-stroke, but for large engines and increasing speeds he thought the four-stroke cycle had the greater advantages and would be used more than the two-stroke cycle.

Mr. Gibbons, who continued the discussion, spoke on the subject of large gas engines, pointing out that the development of the steam turbine and the heavy capital cost of gas engines had militated against their success. In connection with internal-combustion turbines he could not see how the difficulty of obtaining the necessary degree of compression could be got over and without compression it was not possible to obtain economy.

The next speaker, Mr. A. H. Lymn, said his paper, which dealt with the application of gas producers to large-scale power production, had, by some mistake, been included in section C, relating to the preparation of fuels. In this paper, which is referred to on page 39 *ante*, he had dealt with the construction and method of operation of the Holzwarth internal-combustion turbine, of which he said there was a 5,000 kw. set in existence in Germany, and this set had been in operation. The calculated thermal efficiency of this set was 21 to 22 per cent. and the actual efficiency obtained with a smaller 300 kw. oil-driven turbine, on the same system, was 18 per cent. Mr. Lymn also remarked that Professor Stodola had stated in his book that thermal efficiencies up to 29 per cent. might be expected from internal combustion turbines.

Mr. J. L. Chaloner pointed out that while the high compression oil engine was just being developed for high powers, large powered gas engines had been constructed and had given satisfactory results for

many years. He attributed the difficulties in connection with the former to the higher compression pressures necessary, remarking that while high compression increased efficiency it did not improve reliability. The use of high-pressure steam for fuel injection, Mr. Chaloner stated, would require much investigation to ensure reliability, and he also pointed out that flexibility was necessary with any method of injection to allow for the use of different fuels.

The discussion was continued by Captain H. A. D. Acland, whose remarks related mainly to the Still engine. For this engine, he said, Captain H. R. Sankey had estimated an over-all efficiency of 40 per cent. and a consumption of 0·353 or 0·354 lb. of Diesel oil per brake horse-power hour. These estimates had been closely realised on the test bed, the consumption coming out at 0·356 lb. per brake horse-power hour. It was theoretically and practically possible to obtain a much higher efficiency than 40 per cent., but at the cost of simplicity. For the first application of the system to marine work, fuel saving was not the most important factor; it was necessary to make the design as straightforward as possible. Supercharging was essential to obtain the highest fuel economy, but the valve gear necessary for this would increase the complication. The greatest advantages of the system were the manœuvring power and the avoidance of the use of compressed air. In the matter of heat stresses referred to by a previous speaker, Captain Acland pointed out that these were not so dependent upon temperature *per se*, as upon temperature differences. The difference in temperature between the inner and outer surfaces of the cylinder walls of the Still engine was only about 40 deg. or 50 deg. F., and the resulting heat stresses would be negligible. If metallurgists, he added, could produce a cast-iron with good wearing properties and having better thermal conductivity than was at present available, it would be more advantageous for internal combustion engine cylinders than one having great tensile strength.

Professor Hubendick, referring to Mr. Lymn's remarks, said he was surprised to hear that Professor Stodola had predicted a possible efficiency of 29 per cent. for the internal combustion turbine, as the speaker, in conversation with Professor Stodola, had understood the latter to say that high efficiencies would not be possible. There were, however, other considerations than efficiency and the speaker therefore thought that uses would be found for this type of prime mover, but it would not be possible to employ internal combustion turbines if fuel economy became a question of primary importance in the future.

Mr. F. H. Clough, who spoke as an electrical engineer, asked if it were not possible to design Diesel engines to run at higher speeds than those usually employed, in order to increase their scope, and in answer to this, Professor R. E. Mathot gave a brief account of some of the difficulties he had experienced in endeavouring to produce a high-speed oil engine for use on motor vehicles. The engine, he said, had given good results as regards starting and flexibility, but could not be made to run satisfactorily for more than about an hour, so that it had to be abandoned as a complete failure. He added that in order to obtain greater fuel economy with motor lorries, investigations were now being made of the behaviour of these vehicles running on suction gas and using charcoal in the producer. Good results had been obtained, the fuel cost being only about one-third of that of petrol. The only trouble experienced was that the power of the engine was somewhat reduced.

This completed the discussion on the papers, and after Dr. M. Kamo had briefly explained the position of the internal combustion engine in Japan, the meeting was adjourned.

SECTION H.—DOMESTIC AND INDUSTRIAL USES OF POWER.

IN the afternoon of Tuesday, the 8th inst., a number of papers were read and discussed at a meeting of Section H, under the chairmanship of Mr. Bellaar Spruijt, President of the Association of Directors of Electrical Trades, Holland. The chairman stated that he considered the section to be one of the most important, since the papers presented—and they were considerable in number—dealt with the consumers of current, who to his mind formed a leading factor in all electrical undertakings; the consumers had to be served well and their further needs had to be investigated.

The first paper taken was by Dr. W. Lulofs and dealt with the "Latest Developments in the Use of Electricity for Heating Purposes in general, and especially for Domestic Purposes." The developments referred to applied to Holland, and particularly to Amsterdam. Apart from lighting and industrial applications, they covered the use of current in agriculture, dairies, &c., for the heating of homes and public buildings such as schools and churches, for cooking and other domestic work, for water heating, &c. It was estimated that in Amsterdam during the present year 22,500,000 kw.-hours would be used for domestic purposes alone, the estimate for house lighting being an additional 44,500,000 kw.-hours.

Dr. S. Z. de Ferranti said that among the different applications of electricity, the one that would be the most manifest in the future would be the application of electricity to domestic uses. A very large portion of the world's work was done in the home, and the general use of current was the best means for lightening that work. Difficulties, however, presented themselves in this connection, the electrical engineers having to come in contact with a class of users different from those they had usually dealt with hitherto. As an instance of what he meant, he referred to the manufacture of 6-in. shells during the war. Automatic machines were put down, and whilst the machines handled by men lasted well, it had been found difficult to make machines which would withstand the handling by girls. He had often wondered how sewing-machines, very delicate and intricate pieces of apparatus, survived as they did. When they went fully into the question of saving work in the home by the use of electricity, electrical engineers, he believed, would evolve machinery to fit the service it was destined for. One difficulty to be overcome in turning directly to electricity—for cooking, for example—was that electricity was found slower and gave at first a bad impression. In the matter of room heating, we had not been accustomed in this country to heating by means of radiators, and many people thought this a bad system from the point of view of health. The application of current to domestic purposes was a question of very great importance; it was not a separate question, and all electrical engineers should devote a part of their energies to the solving of the difficulties with which it was surrounded.

The next paper, by Mr. J. Sandberg, on "Electric Power in Norwegian Households," covered the same ground as regards Norway. Water power, the only source of power available in the country, had been, and was still being, developed cheaply, thus rendering it possible to undertake the supply of cheap current to households. The domestic utilisation of current in Norway had not been equalled, so far as the author was aware, in other countries. The flat-rate system had been introduced, and the consumer knew what he had to pay annually. He only had to purchase his apparatus and had no further calculations with regard to his expenses.

The third paper was entitled "Technical Development and Financial Organisation, including Co-operative Schemes for Electricity Supply in Agriculture in Denmark," by Mr. F. H. Krebs. The use of electricity in agriculture in Denmark commenced in about 1900 with plants on individual farms. The first real agricultural high-tension plants were erected in 1910–1911. There were now 46 high-tension and 374 low-tension power stations and 92 power stations in the cities and provincial towns. The rural electrification to-day covered about one-third of the farms and rural districts, with about 2·1 million lamps and about 280,000 h.p. in electric motors. The plants were alternating current, 3-phase, 50 periods, the potentials for the high-tension lines varied from 2,000 volts to 20,000 volts for the rural lines and from 25,000 volts to 50,000 volts for the main lines. The paper mentioned a number of low-tension direct-current plants outside 70 provincial towns. The pressure, the summary of the paper stated, was transformed down to 220 volts and 380 volts. The farms used the current for threshing, for grinding corn, maize, &c., for sawing, for lighting, but, as yet, not for work in the fields; it was also used in dairies and slaughter-houses.

Mr. Bellaar Spruijt said that in Holland the pressure at which the current was utilised was usually 220 and 380 volts, a tension that was generally considered dangerous in other countries. In Holland there was no objection to the use of this voltage, and he would like to hear what objections representatives of other countries might have concerning it.

Mr. W. Borgqvist stated that in Sweden they used 220 volts as a lighting voltage as well as 110 to 127 volts. There were more accidents at 220 and 380 volts than at the lower tension. Statistics, however, showed that accidents did not happen in households. Generally few accidents occurred with tensions up to 220 volts; this tension had proved dangerous. Workmen were not often hurt at higher voltages. The insulation was not to blame; the difficulty was to prevent the men from working when the line was alive.

Mr. Bellaar Spruijt here said that in certain conditions a voltage of 120 volts could be as dangerous as one of 220 volts.

Mr. T. C. Thomsen expressed regret at the absence of Mr. B. F. Andersen, since his paper on the "Design of Low-tension Lines and Installations for Rural Electrification" in Denmark dealt with these points. Voltages of 220 and 380 volts were generally used in that country in farming and other work. If reasonable care were exercised in fitting the switches, in making the connections and in the use of suitable material, in every part of an installation, the system could be made very safe indeed. Danish engineers had gone into the subject in great detail, and engineers from other countries on visiting Denmark would be shown the means taken for the prevention of accidents.

Mr. C. Le Maistre found that in Great Britain there was very little co-operation between the current supply companies and the companies which supplied the apparatus. If more co-operation between them existed, standards could be arrived at, the question of maintenance could be gone into and maintenance costs spread over a period. The householder at the present time was in the dark as to the amount of wear and tear the apparatus could undergo.

The Chairman considered Mr. Le Maistre's point an important one, and added that when Dr. Lulofs started his scheme, he started at the same time a repair shop and charged low repair costs; the facility with which repairs were carried out, coupled with reduced repair charges, was greatly appreciated by the current consumers.

Dr. Mailloux said that in the United States they had generally worked at standardising voltages. At the origin it was 70 volts, then 100 volts; it was now 120 volts at the terminals of lamps. There was also now the double potential system, at 240 volts. This meant at the source 125 or 250 volts. Greater safety precautions were needed; no switches should be made in which the live parts were accessible. The tension for motive power was 440 volts alternating current and was satisfactory. But the great majority of cases involved also lighting, and it would, he thought, be a long time before twice 220 volts would be tolerated.

In the course of his reply to the discussion, Dr. Lulofs, referring to Dr. de Ferranti's remarks as to the electric cooker being found slower than gas or coal, he thought they had overcome that in Holland by supplying with every cooker a small water tank combined with an automatic switch which maintained the water in the tank nearly at boiling point, making it possible to obtain boiling water quicker than by using gas. The tank filled itself and was entirely automatic in its action. The hot water used per day in ordinary households in Amsterdam was 10 gallons. The tank contained about 1·5 gallons and was highly efficient. They made a 2-kw. capacity hot plate for cooking which acted as rapidly as the ordinary gas burner, and was easily removable. A device on the water kettles prevented them being emptied completely.

A paper on "Power in the Iron and Steel Industry in America," by Mr. B. R. Shover, was then taken. It gave information on the industry in the United States from which the following deduc-

tions were drawn as to the present and probable future tendency of power generation and application:—(1) Electrification of all power-driven apparatus except blast furnace blowers; (2) substitution of turbo-blowers, or possibly gas engines, for reciprocating steam blowing engines; (3) purchase of power requirements by plants which had no waste heat available; (4) complete economical utilisation of waste heat by means of turbo-generators for electric power generation, except where this heat could be used to better advantage, or had a market value greater than its coal equivalent; (5) interchange of electric power between plants generating power from waste heat and public service companies.

Dr. Carl Köttgen read his contribution on the "Application of Electric Power in the German Industry." This opened with an historical review of electric driving in works and factories, of electrically-driven hand tools, electric cranes, dredgers, &c. The reasons which led to the general use of electric power were low cost at which electrical energy could be produced, coupled with its economical utilisation. Electric drives were found to be the best in every industry and were invariably put down in new plants.

A paper on "Electric Power Plants in the Textile Industry" was then read by Mr. L. Kuhl. It stated that electric energy had long been used in the German textile factories for both light and power. Stress was laid on the advantages of individual electric drives. The application of electric power was reviewed for the various stages in manufacture, and the paper dealt with its use in the blowing-room, the carding-room, with drawing frames, preparing machinery, &c., down to the finished product.

The "Application of Power to Paper Making in the United States" formed the subject of a paper by Mr. A. H. White, who said that in the United States the paper and wood-pulp industry ranked fourth in amount of installed power capacity, but as it was a 24-hour industry it ranked second in power consumed. The primary power installed in that industry totalled 1,851,000 h.p., equal to 16·3 h.p. per employee. Whilst coal was, and for many years would be, the chief source of heat in paper mills, crude oil was being used more and more. Years ago paper-makers began to put down motors in isolated cases for pump driving and for individual drives. Gradually generators were installed in the mills, and with the establishment of hydro-electric plants electricity was used more and more, until to-day there were mills entirely driven by electric power. By 1919 as much as 31½ per cent. of the power used in paper making in the United States was transmitted electrically.

"Electricity Supply of the City and Peninsula of Bergen" was dealt with in a paper by Mr. A. Bjerke and Mr. E. Monsen. It reviewed the development since 1900 in three stages. Up to 1905 the requirements for light in private residences, business houses, and factories took the greater part of the kilowatt-hour production. From 1905 to 1914 electricity was adopted for all interior lighting, and the electric motor succeeded the steam engine and the gas engine in industry. The third, present period, was characterised by the electrification of the homes. During the year 1922–23 42,000,000 kw.-hours were delivered to private houses, equal to 1,680 kw.-hours per household per year, or 4·6 kw.-hours per household per day. Bergen could to-day dispose of about 35,000 kw. and, together with its neighbouring communities, was in possession of waterfalls which were capable of meeting a future maximum demand of 150,000 kw. The average selling price was 4*d.* per kw.-hour for light, 2·6*d.* for industries having a consumption of a few hours, 0·73*d.* for those having many hours of consumption, 0·6*d.* for combined domestic use. A lively competition was now taking place between electricity, gas, and other fuels as to which of them was finally to supply heating for domestic and industrial purposes. The paper gave data on several of the power plants.

Mr. M. Shibusawa contributed a paper on the "Present Situation of Electrical Undertakings in Japan." It stated that the pioneer work of introducing electricity in Japan was done by the Tokio Electric Light Company, who supplied electricity for lighting a part of Tokio in 1887, using a few Edison dynamos each having a capacity of 10 kw. In May, 1891, an hydraulic-power plant was completed in Kioto, using water from Lake Biwa. In February, 1895, the first electric railway to be supplied from water power was started in Kioto. In 1899 the first two long-distance transmission lines were installed, and began operating successfully. At first, therefore, current was used only for lighting; as water power developed, reducing the cost of production, the application of electricity was gradually diverted to power. The existing electric railways were limited to urban, suburban, local lines, and short lengths of the main lines. Last year the Diet passed a Bill for the electrification of the line between Tokio and Kobe, about 370 miles. Electric power was also now being applied to chemical and other industries. The recent earthquake did very serious damage to the electrical installations; fortunately, little damage was done to the water-power stations, these having been outside the earthquake zone. A large amount of water power awaited development in Japan.

The last paper read was on the "Electricity Supply of the City of Kristiania," by Mr. R. Steen, who stated that the capital of Norway was the centre of the country's business life, especially with regard to shipping, trade, and industry. The Kristiania Electricity Works commenced operations in December, 1892, and consisted at that time of a small steam plant of about 1,200 i.h.p. and direct-current machines, supplying about 3,000 incandescent lamps, some street lamps, and a few motors. In December, 1923, the power consumption in Kristiania reached about 47,000 kw., or about 180 watts per inhabitant. The entire consumption for that year was about 200,000,000 kw.-hours. All lighting was now electric, and practically all machinery was operated electrically. The town took its supply partly from its own steam plant, partly from other, hydro-electric stations.

The other papers which we can only briefly notice include: "The Utilisation of the Power Resources of Austria with Special Reference to the Consumption of Electric Power," by Mr. E. Karel, which stated that water falls worth developing in that country would develop about 3,000,000 h.p.—annual average output. The water falls utilised up to the end of 1923 were estimated at about 400,000 h.p. Sir Alexander B. W. Kennedy contributed "Some Notes on the Future of Electric Supply and Demand"; there was no reasonable doubt, Sir Alexander said, as to the future enormous increase of demand for electricity on account of domestic appliances of all sorts. In London the demands for supply for domestic purposes at a cheap rate were increasing twice as fast as those for lighting at full rate. The paper reviewed generally the various conditions which governed the production and distribution of electrical energy. "Electricity Rates in Norway" formed the subject of a contribution by Mr. J. A. Haga. The situation in Rhodesia was dealt with in two papers—one by Mr. B. K. Ward, on the "Utilisation of Electric Power in Bulawayo and District"; the other by Mr. C. H. Baskerville, entitled "Development of the Use of Power in Southern Rhodesia for Industrial and Domestic Purposes, with particular reference to Electric Power." Mr. Ward stated that the electric supply was in the hands of The Bulawayo Waterworks Company, Limited, whose system was 3-phase, 50 cycles, 2,300 volts primary, transforming to 400 and 200 volts for power and 115 volts for lighting. In special cases a 2,300-volt supply could be given. The total sales for 1922, the last completed year, were 444,748 units, including 265,043 units for lighting. The rates for power varied from 5*d.* to 1½*d.* per unit, according to the quantity used and the hours during which current was taken. Mr. Baskerville said that power users in Rhodesia were restricted to utilising coal, wood, charcoal and certain waste agricultural products. Hydraulic power could not be generally considered, and the manufacturer had to choose between steam or gas; if he were situated in or near one of the five larger towns he had a further choice of electric power, provided by the several municipalities. Small suction-gas installations were a popular source of power for smaller plants in rural districts, the only serious rivals in the towns being electric power supplied by the municipalities. "Power for Textile Mills" in the United States, was dealt with by Mr. C. T. Main, who said that the chief items of the cost of textile manufacture were material and labour; the cost of power was rarely over 5 per cent. of the total cost of the product of a mill. Nearly all the textile mill installations now being built provided electric power transmission. "The Utilisation of Power in Canada" formed a detailed symposium collated by Mr. P. T. Davies, dealing with the domestic use of electricity in Canada, and its employment in a large number of industrial undertakings.

On the motion of the chairman, Mr. Bellaar Spruijt, all the authors received the thanks of the meeting for their contributions.

Section K3—Power for Transport (Road Transport and Aviation).

The sub-section relating to power for road and air transport met on Tuesday afternoon, the 8th instant, under the chairmanship of Sir Charles Morgan, the President of the Institution of Civil Engineers. The programme included five papers, and, in opening the meeting, the chairman said he proposed to take them in numerical order. He assumed that they had all been read by the members present, but he would give a brief outline of each.

The first paper was that by Mr. G. Agnelli on "Internal Combustion Engines for Motor Transport and Aviation," which also formed part of the programme of Section E (Internal-Combustion Engines) and has been referred to above in connection with the proceedings of that section. In the absence of the author, this paper was passed over. The next paper was by Col. R. E. Crompton, and was entitled "Power Applied to Road Transport." In this paper, which the chairman briefly explained, the author traced the history of the development of road transport in this country, dealing with the introduction of the steam vehicle and with the application of the internal-combustion engine to road transport. He also discussed the possibilities of the trackless-trolley system of transport and the uses of storage-battery vehicles, calling attention to a somewhat unexpected fact in connection with the latter, viz., that the useful load carried was remarkably high in proportion to the total moving load. Finally, a comparison was given of the cost of transport by petrol, steam and electric vehicles, the cost ranging from 2·59*d.* per ton mile with a 2-ton petrol or paraffin lorry, to 1·14*d.* per ton mile with a 6-ton steamer, drawing a 4-ton trailer.

Invited by the chairman to make a few remarks, Col. Crompton said he had refrained from discussing the roads question, but wished to emphasise the point that, in any system of electrical power distribution, consideration must be given to the trackless-trolley vehicle. With electrically-driven vehicles, he added, the uniform drive of the motor greatly augmented the durability of the vehicle, not only of the transmission system but also of the body work and tyres.

There was no discussion in this paper, and the next paper taken was that of Mr. Alec Ogilvie on "The Application of Power to Air Transport." The author, who was unable to be present, was represented by Major R. H. Mayo, who said he wished to emphasise one or two of the important points of the paper. The dominating factor in aerial transport, he said, was the question of weight per horse-power. It was vital to keep the weight down to the minimum since the weight determined the efficiency of the aeroplane and the amount of useful load which could be carried. The aeroplanes employed on the Continental services could carry a total load of about 16 lb. per horse-power, of which total only 3 or 4 lb. was useful paying load. The weight of the power unit alone was certainly not less than 3 lb. per horse-power, so that it was obviously important to keep it as low as possible; an addition of 1 lb. per horse-power to the weight of the power plant would reduce the paying load by 25 per cent. The speaker expressed the view that the crude-oil engine would not find application for smaller aircraft on account of its increased weight, although for long-range aircraft and airships an increased weight of plant might be

7-METRE SOLAR SPECTROGRAPH FOR POULKOVO OBSERVATORY.

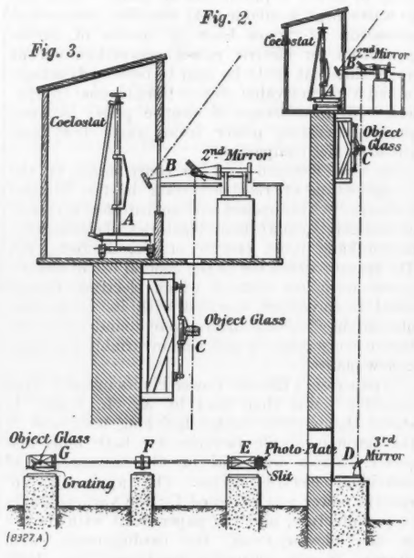
CONSTRUCTED BY SIR HOWARD GRUBB AND SONS, LIMITED, ST. ALBANS, HERTS.

(*For Description, see Page* 87.)

FIG. 1. EXTERIOR VIEW OF OBSERVATORY.

Fig. 2.

Fig. 3.



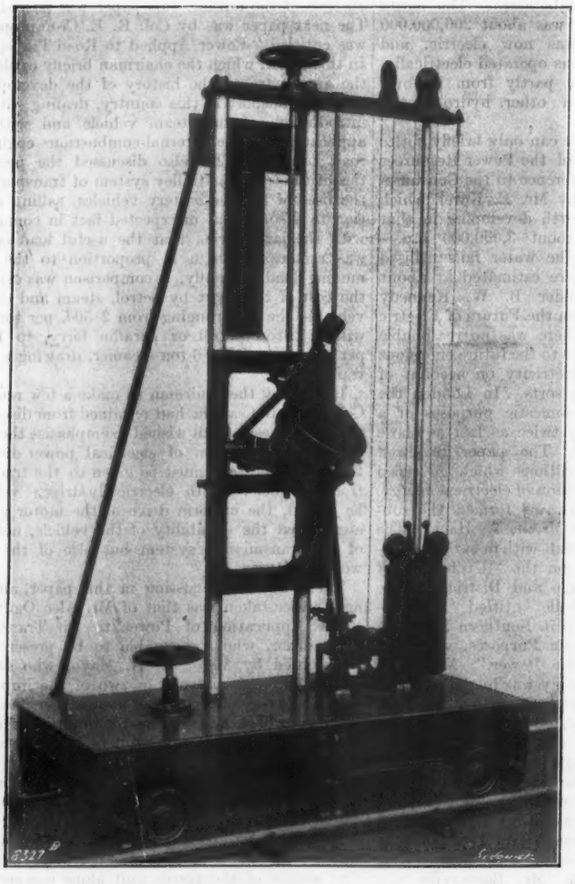


FIG. 4. COELOSTAT AND DRIVING CLOCK.

FIG. 5. SECOND MIRROR AND ITS MOUNTING.

permissible on account of the saving in fuel costs. The question of weight was of even greater importance than that of increasing reliability, which was already reasonably good although capable of improvement. The improvement, however, must not be made by increasing weight. There was not much room for improvement in airscrew efficiency, and but little likelihood of new methods of power transmission being introduced. The system of driving airscrews by gearing from a central engine room, the author regarded as not very promising owing to the extra weight involved, viz., about 1 lb. per horse-power. Finally, attention was drawn to the need for developing large power units, the speaker mentioning that a 1,000 h.p. engine, already in service, was by no means too large. He thought that engines up to 2,500 or 3,000 h.p. could be usefully employed.

Mr. Ogilvie's paper gave rise to no discussion, and at the conclusion of Major Mayo's remarks the chairman gave a *resumé* of Dr. H. S. Hele-Shaw's paper on "Variable Transmission Gears," which formed the next item on the programme. Dr. Hele-Shaw's paper discussed the advantages and disadvantages of frictional, mechanical, electrical, pneumatic and hydraulic variable transmission gears and pointed out, in conclusion, that one problem in variable transmission of particular interest and importance at the present time was its application to heavy locomotives. There were large tracts of the world where the steam locomotive could not be employed owing to absence of water and where electric traction was out of the question. The internal-combustion engine had been successfully applied in small units for road

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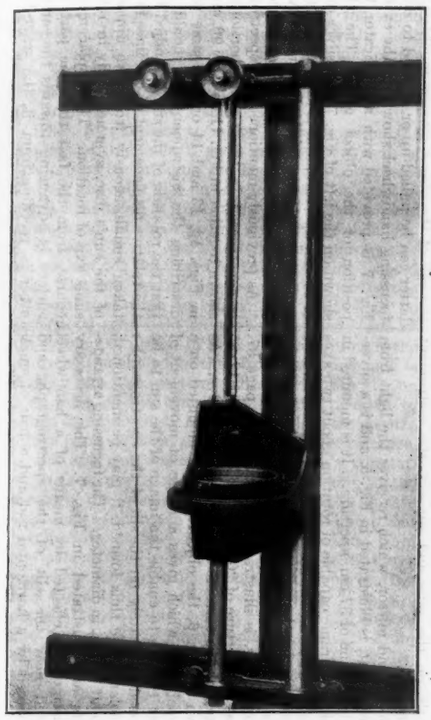

FIG. 6. MAIN OBJECT GLASS.

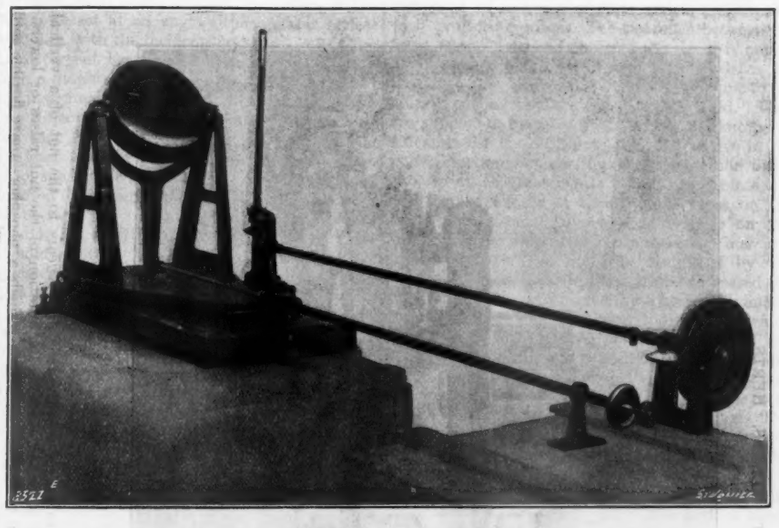

FIG. 7. THIRD MIRROR AND FOCUSSING GEAR FOR MAIN OBJECT GLASS.

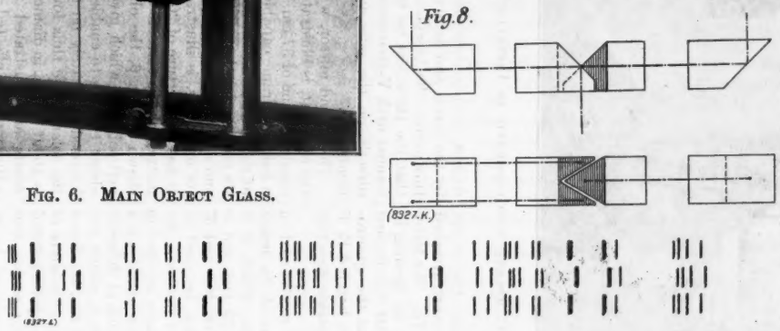

FIG. 9.

locomotion and in large units for marine propulsion, but there was no indication at the present time of the production of an internal-combustion engine having sufficient flexibility for use on railway locomotives. For this, and other, reasons the subject of variable transmission gears was a very suitable one for discussion.

Invited to speak by the chairman, Dr. Hele-Shaw said he thought that variable transmission gears would become more and more important in connection with the development of the internal-combustion engine. Variable transmission was not required with the steam engine on account of the flexibility of the latter, and was not necessary in some applications of the internal-combustion engine. It was, however, required for land transport, especially on roads, and had, in fact, made road transport by internal-combustion engines possible. Dealing briefly with the main headings of his paper, Dr. Hele-Shaw referred to the Constantinesco gear described in the paper under the heading of intermittent mechanical variable gears.

The first speaker in the discussion on Dr. Hele-Shaw's paper was Professor Constantinesco, who remarked that the over-all efficiency of the Hele-Shaw gear was about 90 per cent., so that the efficiency of the pump alone was about 95 per cent. The pump was therefore practically a perfect machine from the mechanical point of view. The problems of variable transmission, however, were not so much connected with efficiency as they were with rendering the gear automatic. The speaker had tried to solve the problem of leaving the gear ratio to adjust itself automatically, by means of a mechanical device. He had, at first, employed hydraulic transmission, but was now using the device comprising a pendulum and ratchet gear described in Dr. Hele-Shaw's paper. With regard to the ratchet motion, the speaker remarked that there was considerable prejudice against it, but it must be remembered that power was always transmitted in a series of pulsations.

Colonel Crompton, the next speaker, said that Dr. Hele-Shaw apparently regarded friction variable gears as only suitable for low powers, but he (the speaker) had had a 25-h.p. tractor with friction gear working satisfactorily for many years. In connection with change-speed gears for motor vehicles, it was necessary to consider the comfort of the passengers, and, in this respect, motor omnibuses fitted with electrical transmission showed a marked superiority over those with mechanical change-speed gears. The only perfect change-speed gear for large powers, the speaker considered, was the Ward-Leonard system which he briefly explained. In conclusion, Colonel Crompton remarked that the reason the internal-combustion engine had been so greatly developed for road traction was not the failure of the steam engine, but because the former had been introduced at about the same time as rubber tyres had made their appearance in France. He thought equally good results could have been obtained with the steam engine.

In answer to Colonel Crompton, Dr. Hele-Shaw said he did not regard the 25-h.p. mentioned as a large power, and that the jerks experienced in motor omnibuses were due more to the clutch than to the change-speed gear. He thought Colonel Crompton would agree that an hydraulic lift started more easily than an electric lift.

The last paper to be dealt with was by Mr. H. G. Burford, and its subject was "The Influence of Road Conditions on the Development of the Modern Motor Vehicle." As this paper had only just become available, the chairman invited the author to give a summary of it. The paper, of which an abstract will be given in a later issue, first dealt with the road improvements made in this country during recent years, and then discussed the effect of road conditions on the design of commercial motor vehicles. Making suitable allowances for road resistance, gradients, engine characteristics, &c., the author estimated the power required for commercial vehicles with load capacities ranging from 1 to 6 tons. The question of fuel economy was also considered at some length. In conclusion, the author stated that had there been no increase in the standard of users' requirements, the road improvements made during the last 10 or 12 years would have reduced the engine power necessary for a given service by about 18 per cent. The cost of tyre maintenance had also been greatly reduced by the same cause.

The discussion on Mr. Burford's paper was opened by Colonel Crompton, who pleaded for extensive research as to the causes of, and remedies for, the corrugation of road surfaces. Mr. J. Muir, who followed, ascribed road corrugation to the employment of rigid wheels, and Mr. E. J. Wheldon called attention to the inability of the usual form of laminated spring to resist the horizontal component of the road shocks. It was not impossible to devise simple mechanical means to absorb the horizontal shocks, but the speaker was convinced that the best solution would be to adopt the principle employed in railway transport of hauling goods instead of carrying them. Road transport, he said, should be carried on by separate self-propelled vehicles hauling trailers behind them.

This completed the business of the section and the meeting was then adjourned.

We will continue our report of these meetings in our next issue.

7-METRE SOLAR SPECTROGRAPH FOR POULKOVO OBSERVATORY.

THE solar spectrograph described below and illustrated on this page, and on pages 86, 88 and 96, was designed shortly before the war by Sir Howard Grubb and Sons, Limited, then of Dublin, in collaboration with Dr. Belopolsky, of Poulkovo, which is situated near Petrograd, and is the chief Russian

7-METRE SOLAR SPECTROGRAPH FOR POULKOVO OBSERVATORY.

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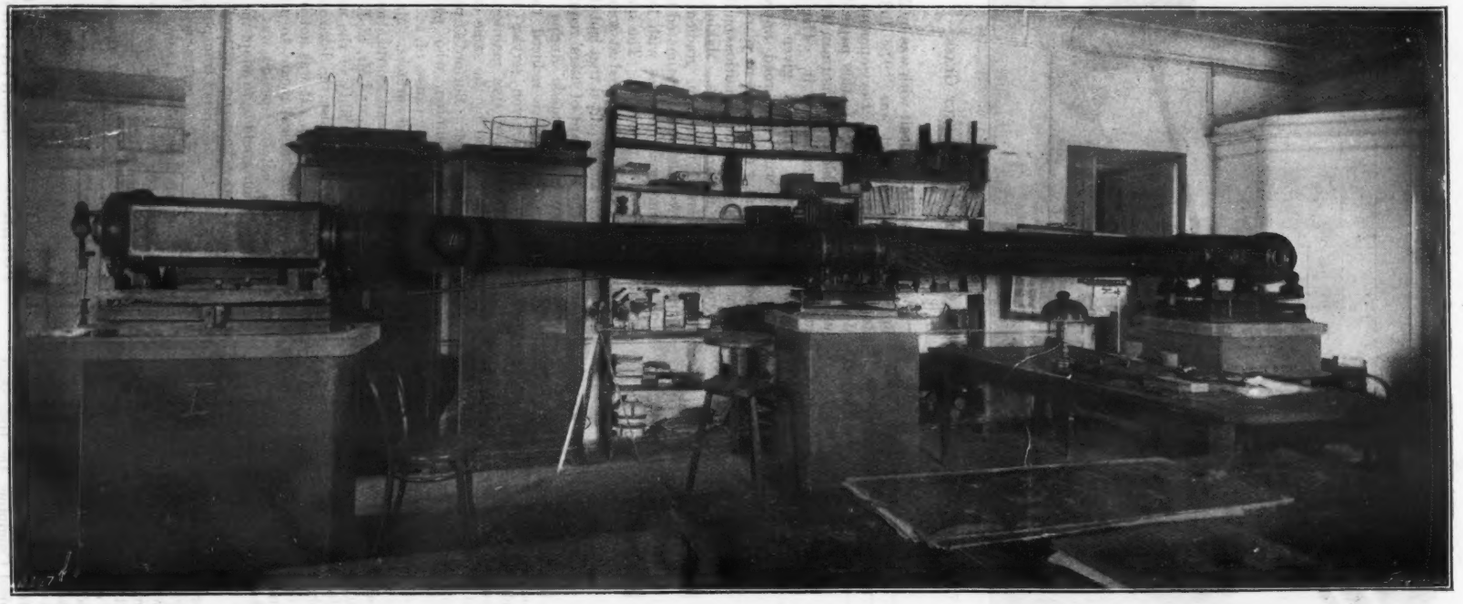


FIG. 10. COMPLETE SPECTROGRAPH AS INSTALLED.

astronomical observatory. The construction of the instrument was delayed on account of the war, but it was completed a few months ago at Messrs. Grubb's new works at St. Albans, and has since been erected at Poulkovo. The spectrograph, which is intended primarily for observations of the rotation of the sun, is of the Littrow or auto-collimating type, and its design is based on that of the 30-ft. tower spectrograph at Mount Wilson Solar Observatory, although the arrangement has been modified in some respects to comply with the conditions existing at Poulkovo.

An exterior view of the Astrophysical Building at Poulkovo, in which the instrument is installed, is reproduced in Fig. 1, and Fig. 2 is a diagram illustrating the general arrangement of the essential parts, some of which are shown to a larger scale in Fig. 3. In these diagrams, A is a coelostat which is mounted in a housing erected on the south wall of the building, as shown in Fig. 1, and provided with sliding windows on the south side. The coelostat consists essentially of a plane mirror moved by clockwork mechanism in such a manner that light from the sun is always directed on to a second plane mirror, lettered B in Figs. 2 and 3, irrespective of the apparent motion of the sun due to the earth's rotation. From the second mirror B, the light is reflected vertically downwards through the object glass C, which is supported on a framework attached to the wall, on to a third plane mirror D. The latter directs the light horizontally through an opening in the wall, so that the image of the solar disc formed by the object glass falls on the slit of the spectrograph, the three main parts of which, lettered E, F and G in Fig. 2, are mounted on separate concrete piers in a room on the ground floor.

A photograph of the coelostat is reproduced in Fig. 4, from which the main features of its design can be readily followed. The mirror, which is of silver on glass, has an aperture of 25 cm. and is adjustable for any latitude between 60 deg. and 37 deg. in order that the coelostat may be used at Simeis Observatory, in the Crimea, if desired. By means of a screw and handwheel, shown at the top of Fig. 4, the mirror can be moved up and down a vertical slide to suit the sun's declination at different periods of the year. The driving clock, which can be seen on the baseplate to the right of Fig. 4, is fitted with the Russell control, and is designed to allow of a continuous run of 6 hours. The baseplate is fitted with wheels running on rails of circular section, laid due east and west to enable the coelostat to be placed in the best position to suit the morning or afternoon sun, but the wheels are carried on pivoted frames, so that they can be raised clear of the rails by the screw and handwheel shown in Fig. 4. By this means, the baseplate can be lowered slightly so that the three feet on each side (two of which are formed with V-grooves while the third is flat), rest directly on the rails and support the instrument firmly.

The second mirror, which receives the light from the coelostat, is illustrated in Fig. 5, and is a silver-on-glass plane of 37 cm. aperture. It is mounted in a balanced frame capable of rotation about two axes at right angles and fitted with slow motions, so that its position can be accurately adjusted to direct the sun's rays on to the object glass; the latter, with its mounting, is illustrated in Fig. 6 on page 87. It has an aperture of 20 cm., a focal length of 12·85 metres, and is corrected for photographic rays. As shown in Fig. 6, the object glass is mounted on a vertical slide which gives a range of movement of about 1 metre to enable the image of the sun to be focussed accurately on the slit of the spectrograph; the solar image thus formed, it may be mentioned, is about 10 cm. in diameter. The focussing arrangements are illustrated in Fig. 7. The necessary adjustment is effected by means of a handwheel located near the slit of the spectrograph, and connected by a horizontal rod and a pair of small mitre gears to the nut of a vertical screw. The rotation of the nut raises or lowers the screw to which a phosphor-bronze flexible cord is attached, and the cord is carried up over the pulleys, shown at the top of Fig. 6, and down to the carriage on which the cell of the object glass is mounted, so that the latter can be pulled up or allowed to descend. The focussing handwheel shown on the extreme right of Fig. 7 is provided with an indicator to show the position of the object glass. The third mirror, shown on the left of Fig. 7, is a silver-on-glass plane of 25 cm. aperture, and is carried on an alt-azimuth mounting with slow motions actuated by handwheels placed close to the focussing handwheel.

As previously mentioned, the spectrograph proper is constructed in three main portions, which are shown together in Fig. 11 on page 96, and separately in Figs. 12, 13 and 14 on the same page. Before describing the instrument we should first explain that the rotation of the sun is studied by measuring the relative displacement of the lines in two spectra taken simultaneously from two opposite portions of the sun's disc, symmetrically in relation to the sun's axis of rotation. The displacement results, of course, from the fact that one part of the solar surface is advancing towards the earth, while the other is receding from it, the wave-length of the

light from the advancing portion being diminished by the motion of the light source, while that from the receding portion is increased. The phenomenon is known as the Döppler effect, which is commonly observed in the case of sound waves by the drop in pitch which takes place when a locomotive sounding its whistle passes the observer. When the sound source is advancing towards the observer the pitch of the note is increased and *vice versa*, and of the two sounds heard under these conditions one is higher and the other lower than would be heard if the sound source were stationary.

When it is desired to make observations on the rotation of the sun, a plate carrying a system of four prisms for bringing the images of the opposite limbs of the solar disc on to the slit of the spectrograph is mounted in front of the slit. The form and arrangement of these prisms are illustrated in Fig. 8, on page 87, the chain dotted lines representing the path of the light rays and the slit being located below the two central prisms which fit partly one between the other as shown. It will thus be understood that light from the right-hand side of the system, as drawn in Fig. 8, passes through the centre of the slit while that from the other side is divided into two portions which enter the slit on both sides of the centre. It is thus possible to obtain simultaneously on the same plate the spectra of two parts of the sun's surface, such, for instance, as the east and west limb of the sun's equator, or, in fact, any other two parts, according to the setting of the prisms. The resulting spectra appear somewhat as shown in Fig. 9, in which the top and bottom rows of lines represent the spectrum from one part of the solar disc while the central row represents the spectrum from the other part. The lines forming the central row, it will be seen, are displaced to the right relatively to the top and bottom rows owing to the effect explained above. From accurate measurements of the extent of this displacement it is possible to determine the relative velocity in the line of sight of the two portions of the sun's disc from which the spectra emanate, and in this way the rotation of the sun can be investigated. It has been determined that equatorial points of the sun are moving with a speed of about 2 kilometres per second, and the apparatus we are now describing, used in conjunction with a suitable diffraction grating, will give from one spectrogram a velocity measurement of greater accuracy than $\frac{1}{10}$th of a kilometre per second in the line of sight.

The front portion of the spectrograph, which is illustrated in Figs. 11 and 12, consists of a box-shaped casting with openings in each side and having, at each end, accurately turned circular portions. The latter rest on anti-friction rollers running in ball bearings, so that the whole casting can be rotated about a horizontal axis. The other two main parts of the instrument are similar castings similarly mounted, and all three parts can be rotated together by means of the handwheel shown on the extreme left of Fig. 11. This handwheel is connected by an inclined tubular rod, having universal joints at each end, to reduction gearing which engages with a toothed ring on the central part of the instrument as shown in Fig. 14. Horizontal rods connect the reduction gearing of the central portion to pinions engaging with toothed rings mounted on the front-end and rear-end parts of the instrument, and since these rods are identical in length and diameter, the twist due to the torque will be equal in each case. With the arrangement adopted the two end parts will rotate together exactly, which would not be the case if the drive for the three pinions were transmitted along a rod from one end.

By turning the instrument as described it is possible to bring any part of the solar image, which, of course, is kept stationary, on to the slit. The latter is mounted on the axis of rotation of the instrument on a breechpiece forming the outer end of the front casting, and the breechpiece also carries the photographic plate holder which is mounted off the centre; both the slit and the plate-holder can be seen in Fig. 12. The slit is 20 mm. in length and is arranged so that both jaws are moved simultaneously by means of a screw to adjust the width of the opening. The plate holder, which takes plates 24 cm. long by 4 cm. wide, can be moved laterally by means of a milled-head screw so that four or five narrow spectra can be taken on the same plate, and the width of the part of the plate used in any single exposure can be adjusted by another milled-head screw which actuates a slit extending over the full length of the plate. The holder can also be tilted so that the surface of the plate can be set at an angle either greater or less than 90 deg. with the incident light.

The divergent beam from the slit, after passing through a diaphragm carried by the central portion of the instrument, is rendered parallel by a collimating object glass of 10 cm. aperture mounted in the rear end part, the distance between the object glass and the slit being equal to the focal length of the former, viz., 706 cm. The object glass, is corrected for photographic rays and is focussed by means of rack and pinion gear fitted with a scale for reading its position. Beyond the object glass is a holder fitted with all necessary adjusting arrangements for the diffraction grating, on which the parallel beam falls and from which it is reflected back again, through the object glass and central diaphragm, to the slit end of the instrument where it comes to a focus on the surface of the plate in the form of a spectrum owing to the dispersion effected by the grating. The inclination of the grating holder can be adjusted from the front end of the spectrograph by means of a rod turned by a handwheel mounted on the breechpiece and shown near the upper left-hand corner of Fig. 12; a circular scale and verniers are provided for reading the inclination of the grating.

In concluding our description of the instrument, we may mention that graduations are cut on the periphery of the breechpiece at the front end, so that its angular position about the horizontal axis can be read by means of a vernier fixed to the base plate. The base plates on which each of the three main parts are mounted are provided with adjustments so that they can be set coaxially. To facilitate the setting, special brackets, which can be attached to the circular ends of the front and rear castings and which carry a telescope and collimator, have been supplied. Fig. 10, on page 88, is a view of the complete spectrograph as installed in the Astrophysical Building at Poulkovo Observatory.

THE MACHINERY OF THE COTTON MILL AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 13.)

AFTER leaving the scutcher, the cotton fibres have been freed from most of the impurities, such as husk, stalk, leaf and dirt which were originally present. It must not be assumed, however, that the material is completely clean, for the entanglement of some of the fibres has retained foreign matter in such a way as to prevent it being freed by the simple processes of opening and scutching. An examination of the material at this stage shows the presence of broken, short and immature fibres and many small entanglements or knots caused by the varied motion of the fibres in the gin. To overcome these defects, the cotton is subjected to the operation of carding. The process consists in the removal of the cotton fibres from one revolving drum to another on both of which they are held by fine metal wires. The fibres are finally removed from the large drum by a belt composed of a series of flats provided with steel wire projections similar to those of the drum. In the course of these interchanges, the fibres are all straightened out, the final deposit of impurities takes place and the cotton fibres of short length are rejected. How the process is carried out in practice may be discussed in relation to an actual machine. Fig. 14, on Plate IX, illustrates a machine of this type made by Messrs. Elijah Ashworth, of Moss Brook Works, Collyhurst, Manchester.

Before referring to the special constructional features of this carding engine it will perhaps be advisable to trace the passage of the cotton through the machine. The lap from the scutcher is fed forward by a roller at the left-hand side of the machine, as illustrated, and is directed under a rapidly revolving cylinder known as the taker-in. This is provided with saw teeth which separate the fibres and carry them round to reach a large revolving drum covered over its whole surface with fine wire points. Here the fibres are removed from the take-in roll and carried round on the drum, above the top part of which is provided a band composed of a series of flats which are covered with projecting wires. The clearance between the wires of the flats and those of the drum is only a few thousandths of an inch. A chain drive for the flats is provided at each side of the machine to the links of which chain the flats are connected. They are supported by an adjustable surface known as a flexible bend. Both flats and drum move in the same direction but at different speeds, the drum moving at the faster rate. The wire points are bent in the middle of their length, those on the drum in a forward direction and those on the flats in a backward one. The opening out and straightening of the fibres is completed by the combing process, and after the drum has passed the flats, the fibres are removed by a smaller cylinder, with wire points set very closely together, known as the doffer. As the fibres are carried around the doffer they finally reach a position where a rapidly reciprocating comb removes them and they are gathered together into a sliver—that is, a rope form—by a passage through a funnel and rollers. The sliver is then coiled up in a cylindrical can or container prior to removal for the performance of the processes of drawing.

In the Ashworth carding engine, Fig. 14, there are many features of interest. The first of these is the method of driving which is arranged to cut down the pressure on the cylinder bearings caused by the driving straps. The aim is, of course, to prevent side wear in the bearings, and thus make continuous running possible without unsteadiness. Actually, this is achieved by interposing a bush driven by the fast pulley, which drives a clutch held on to the drum shaft by means of arms which fit in recesses. The cylinders are cast in longitudinal halves, which include the arms of the star wheels. Eight strong and accurately-fitted bolts secure the halves together, and the holes for the shaft are bored out after assembly in the same operation, to ensure concentricity. By this construction, cores are avoided in the casting work, and, as smooth iron patterns are used, the castings are much more regular and require very little adjustment to ensure perfect balance. Arrangements are provided to ensure that the steel wires on the drum can be adjusted to give a perfectly circular and concentric form, and a grinding apparatus, fitting on the machine above the revolving flats, makes possible the provision of a true working surface. A brush cleaner, run at a speed to ensure that its bristles pass through the wires of each flat many times in the ordinary course of working, makes for effective cleaning and causes very little dust. What is termed a flexible bend in an ordinary carding engine is replaced, in this case, by the use of the underside of the side frames of the machine, which are carefully lathe-turned for the purpose. To compensate for the wear in the cylinder bearings which would upset the concentricity, pedestal screws are used by means of which the cylinder can be raised or lowered. On the bends are placed, one over the other, four or five bands of hardened and tempered steel bearing numbers which indicate their thickness. By their use in association with the pedestal screws, exact adjustment to the distance requirement between the flats and drum is possible, and at the same time concentric setting is maintained.

A complete set of carding engines, representing the design suitable for dealing with cotton waste, is shown in Fig. 15, on Plate IX. This equipment, made by Messrs. William Tatham, Limited, of Vulcan Works, Rochdale, comprises an automatic feeding machine, a simple breaker carding engine, a parallel fibre feeder, a finisher carding engine and a leather tape condenser. The machine shown is of 60 in. width, but is made in sizes up to 72 in. By its use much cotton waste is put into utilisable form at a comparatively low cost. The cotton waste is fed into the hopper of the automatic feeder and by means of an inclined spiked lattice, is conveyed upwards and deposited into a weighing pan. This is so arranged that when a predetermined weight of material is received, it opens and deposits the stuff on the feeder of the breaker carding engine. After

the preliminary carding is completed, the material is conveyed by the parallel fibre feeder to the finisher carding engine and presented to it in a web about 18 in. wide. The fibres are not crossed, but retain the parallel form in which they left the first carding process. After the second carding is completed, the web, by means of the leather tape condenser, is split into 160 slivers, which pass between the leather bands having both a forward and a reciprocating motion. By this part of the system, the slivers are rubbed into threads, which are wound on to bobbins ready for the spinning processes.

Attention must now be called to the drawing process, by which the number of fibres in the cross-section of the sliver is reduced and the fibres are made to run parallel to each other. The machine for this purpose is shown in Fig. 16. It is fed with the slivers from the carding engine, and they are passed through guides and over spools and through a pair of rollers from which they pass on through a series of drawing rollers which run at continuously increasing speeds and ensure that the sliver is greatly drawn out. A number of these slivers are then combined into one and passed through calender rolls into the coiler. In the design shown in Fig. 16, which is a product of Messrs. Asa Lees and Co., Limited, of Soho Iron Works, Oldham, there are some special features which should be referred to. First the roller beam is exceptionally strong and of sufficient width to carry the calenders as well as the rollers, without requiring supports at the ends of the stands. All the gearing is covered in with guards which are provided with a locking motion so that they cannot be opened whilst the frame is running; nor indeed can the frame be started until the guards are all closed. A stop motion is provided so that the frame is stopped instantaneously when an end breaks. The spoons and tumblers on the machine are made of aluminium, which, because of its lightness, ensures easy action and makes sensitive balancing a possibility. The process of drawing may be repeated a number of times on similar machines.

When fine yarns are the objective in the work, the slivers from the drawing frame are made into a lap in a sliver lap machine (Fig. 21, Plate XII), and then into a ribbon on a ribbon lap machine, (Fig. 22, Plate XII). The illustration of the sliver lap machine shows a side view of a machine made by Messrs. John Hetherington and Sons, Limited, of Vulcan and Ancoats Works, Manchester. It is made with three pairs of drawing rollers, followed by two pairs of calender rollers for consolidating the lap. The machine has an automatic stop motion working on the same principle as that of the drawing frame, so that stoppage takes place should any breakage of the sliver be caused. The object of the ribbon lap machine, Fig. 22, is to draw six laps made on the sliver lap machine into one. The incoming material is passed through four lines of drawing rollers, each resulting web being then taken over a highly polished curved plate which conducts it on to the front table of the machine, along which it travels at right angles to its path through the rollers. The treatment ensures that the whole six laps are laid one upon each other before they reach the end of the table, on which are arranged a number of press rollers to ensure an even contact of the six component layers of the new lap, which is then thoroughly consolidated by the two pairs of heavily weighted calender rollers and is wound on a bobbin. This drawing process straightens out the fibres and gives a lap of absolutely even section, so that the waste that takes place in the combing process which follows is very small.

Figs. 23 and 24 show a Nasmith comber which receives the lap from the ribbon lap machine, and is used to remove from it any short, curled or broken fibres it contains, and also further to increase the degree to which the fibres have been made to lie in parallel lines. It is simply a process of combing out the irregular or undersized fibres. In the actual machine, the lap is passed through a series of needles mounted on a revolving roller, one side of which is covered by a plain segment. When the combing process is started, the lap is held by nippers which open out immediately, and so reduce the relative speed of the needles and lap to ease the strain on the fibres. When the nippers open, the lap rises automatically and points directly into the space between the first pair of rollers. The height the lap rises is regulated by the action of a top comb which comes down upon it. The nipper then advances and thrusts the fibres into the rolls where they are caught and drawn off, and in the meantime pass completely through the top comb. The rollers continue their rotary movement to an extent sufficient to leave a short combed end projecting from them, and the operations are then recommenced. The overlap of the piecings obtained on this machine is about 2 inches, which is a great improvement on that obtained with earlier types, and the detachment is a slow and continuous process compared with the instantaneous snatch which was previously used. The motion is such that the rollers in the Nasmith machine are only starting up slowly when they seize the nipper tuft. All the motions of the machine, except that for the detaching rollers, are continuous, so that there is only one cam in the machine which runs very quietly, and is proportioned to reduce wear and tear. The product is taken away as an untwisted sliver.

Now that the cotton has been converted from a tangled mass of fibres containing much enmeshed foreign matter into uniform strands free from impurities, and with the fibres of lengths approaching to equality, a continuation of the drawing process, with or without further doubling, takes place. For this the material, if coarse, is taken from the drawing frame and if for fine counts is taken from the comber. As the sliver is now very weak, any further attempt at reduction would make it so delicate as to be unsuited to further treatment. To overcome this a slight twist is given to the sliver and it is then wound upon a bobbin. Many reductions take place before the diameter is reduced to that suitable for spinning. The process is carried out in steps of which the number depends upon the degree of fineness which is required. The machines used in this process have many names. The term "flyer frame" is used generally, but that in which the first action is performed is called a slubbing frame, while the later stages are performed on intermediate and roving frames. Two examples are shown in Figs. 17 and 18 on Plate X. The former illustrates a machine made by Messrs. Brooks and Doxey (1920), Limited, of Union Ironworks, West Gorton, Manchester, and the latter a product of Messrs. Asa Lees and Co., Limited, of Soho Iron Works, Oldham. The slivers are taken into a slubbing frame from the cans, but for the later processes the material is on bobbins from which it is drawn for further attenuation. In either case the slivers are led through rollers by which they are drawn out. The roving is carried to the front of the machine and is passed into one of the flyers. These have two arms and the roving is carried down one of them so that it may be wound on a bobbin mounted on a sleeve surrounding the flyer spindle. Rapid revolution of the flyer causes the roving to be wound on the bobbin, and a vertical movement, alternately up and down, ensures that it is wound in uniform layers. For further attenuation these bobbins are fixed on the creel of the next machine in the series, and so the process is continued until a suitable diameter is obtained. Compensation is, of course, necessary for variation in speed of winding as the bobbin becomes more and more wound, and is obtained by the use of driving between two coned pulleys. The method of carrying the roller bearings in the Brooks and Doxey machine is one of the improvements its design shows. Solid end brackets house the gear for the rollers, and solid bearings are provided for their shafts. Effective elimination of uneven stresses on the roving is ensured, and thus better winding is produced by the control of the differential speed which is obtained.

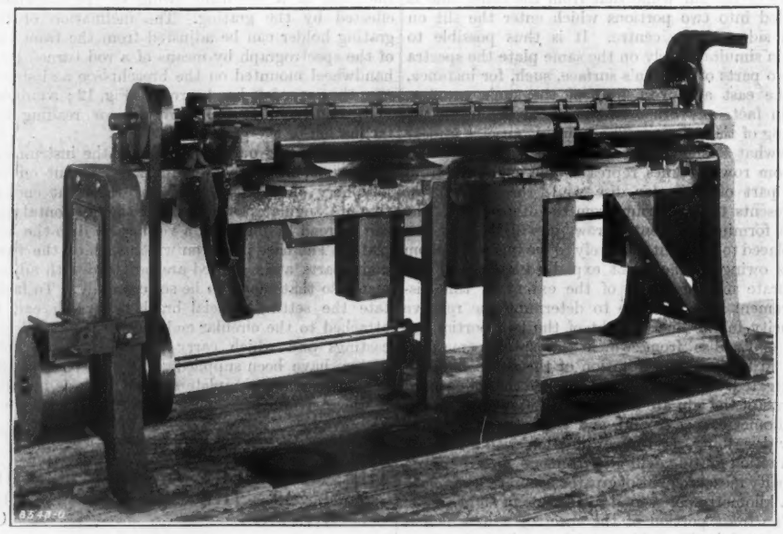


FIG. 16. DRAWING FRAME; MESSRS. ASA LEES AND CO., LIMITED, OLDHAM.

The driving shaft and the bobbin driver run in the same direction so as to reduce friction to a minimum. Exact synchronism of starting of the bobbins and spindles is also arranged for.

The special point about the frame of Messrs. Asa Lees and Co., Limited, is the box casing for the bobbin and spindle rails. The rails are completely cased in by front and back plates, and the front plates on the top rail travel up and down along with the rail behind the plates fixed to the bottom rail. There is consequently no opening between the top and bottom rails even when the top rail is at the highest point of its traverse. The front plates can be easily removed for oiling or gear setting when necessary. The lifter racks are cut from the solid and gear with machine-cut pinions, which are provided with a cast-iron boss fitting in the spring piece and acting as a bearing for the lighter shaft. Self-locking doors enclose the differential motion, the hoist, and the cone drum wheels, and cannot be opened while the machine is running nor can the machine be started until the doors are closed.

The next operation in the chain of cotton processes is that of spinning. In this, additional twist is given to transform the loose fibrous roving into a finished yarn. The previous twist given in the early stages of operation was only introduced to ensure the maintenance of the necessary strength during working, but of such a limited extent as to make further drawing possible. In spinning, the processes of treatment of the cotton fibre are completed, and the twist then given is to consolidate the yarn. The process may be carried on continuously in a ring-spinning frame or intermittently

on a mule. In the spinning frame, the yarn is taken from the bobbin on the creel through a series of drawing rolls, and is then passed through a traveller ring surrounding the spindle. As the spindle is driven it pulls the traveller ring round with it, and while this relieves the tension on the yarn, it puts a twist upon it.

The mule, though a machine in which the twisting actions are carried on intermittently, actually gives better results than the ring-spinning frame. The essential action of the machine is to twist a certain length of the roving, and then to wind it on a spindle on completion and prior to the start of the twist on the next length. Drawing rolls are commonly fitted to increase the attenuation of the roving in the machine. From the bobbins on the creel of the machine, the rovings are first led through the rollers and led to a spindle carried on a part of the machine which is moved to and fro on rails and is known as the carriage. Many hundreds of spindles are provided on the carriage and are driven at a very high speed, something of the order of 10,000 r.p.m. The revolutions stretch at each draw, and thus affect the winding. In the view of the headstock the fast and loose pulley which receives the drive are seen beside the toothed wheel which takes the drive to the ropes of the carriage through the grooved pulleys.

After coming from the mill, yarns are passed on for the purposes of weaving or doubling. In the former case the purpose is the manufacture of cloth, and in the latter the twisting together of two or more strands into a compound form for making sewing cotton and lace, embroidery and other fancy yarns. A doubling frame such as is used for this purpose is shown in Fig. 19 on Plate XI. This resembles a ring spinning frame, and in it the twisting operation is performed in exactly the same way. There are some points of difference, however, for there is no possibility of drawing after the yarns have been twisted in the spinning process, and consequently no drawing rollers are used. The motor drives the tin drum shaft which gives motion to the spindles at each side of the machine. In the English system, the yarns coming from the bobbins are passed down

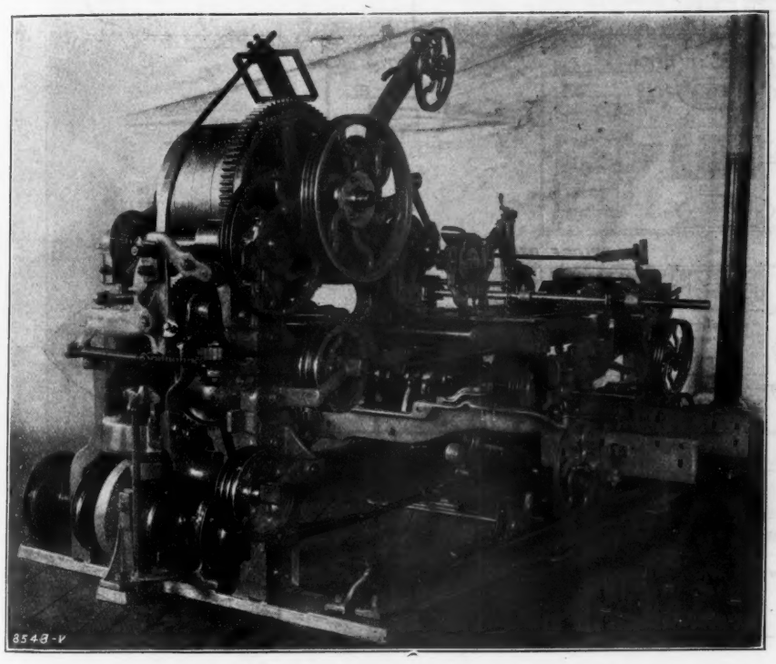


FIG. 25. COTTON MULE HEADSTOCK; MESSRS. ASA LEES AND CO., LIMITED, OLDHAM.

of the spindle cause the twists in the yarn, and the carriage moves away with the spindles rotating as the rollers pass out the yarn. This continues for the whole period of travel. When the carriage returns, the yarn is wound on the spindle. This is accomplished by the use of two curved arms beside the spindle which have projecting wires at their ends by means of which the yarn is guided. At first there are a series of turns of yarn on the top of the spindle. These are uncoiled in the process called backing off, and the wire ends of the curved levers keep the yarn taut during the process. The carriage then starts to move in and the yarn is wound in regular form on the spindle, the bent arm and its faller wire acting as a guide for the process. A slow speed of turning is used for the spindle during this return motion.

The headstock of a mule made by Messrs. Asa Lees and Co., Limited, of Soho Iron Works, Oldham, is illustrated in Fig. 25 on this page. This has many special features, principally to obtain lightness in association with rigidity and strength. Each length of carriage for it is made out of a single sheet. The tin roller, which gives the motion to the spindles on the carriage, is a pressing made from sheet metal and electrically welded to a steel boss. The quadrant is driven by a chain, in place of the usual quadrant band which is liable to into a trough of water and under a glass rod carried by a series of short arms. When the yarn emerges from the bath it is passed through a guide wire and around and between a pair of rollers. The action of the water is to give the yarn solidity, and all loose fibres are smoothed down and incorporated in the doubled thread when twisted. In the Scotch system the rollers are located in the trough, so that the yarn passes directly from the creel to the bottom of the lower roller and then comes out of the water before passing between the rolls. The ring doubling frame shown in Fig. 19 is made to work on either the English or Scotch systems. In the former case the rollers are carried on strong angle beams, while for the Scotch method the beam is dispensed with to permit the fixing of the water trough, and the rollers are then carried from stands fixed on spring pieces. The beams and girder rails on this machine are not only bolted together, but steady pins are inserted at the frame ends, so as to ensure absolute rigidity. For this doubling process the yarn must be re-wound on to bobbins. This is effected in a simple winding frame such as is illustrated in Fig. 20. This machine, made by Messrs. Arundel, Coulthard and Co., Limited, Stockport, will wind up to six ends on each spool. On one side of the machine the arrangements necessary for parallel winding are made, but, in the other, parallel or conical tubes may be formed. The process consists in drawing off the yarn from the old spindle and while it is maintained taut, guiding it through moving guides on to the new spindles in such a way as to produce the desired form.

(To be continued.)

PROPOSED NEW FORD MOTOR WORKS.

WHAT has since been developed into one of the largest and most interesting industrial organisations in the world, viz.: the Ford Motor Company, came into existence just over 21 years ago, on June 16, 1903, to be precise, and the twenty-first anniversary of the concern coincides very closely with another interesting event in its history, which was the completion of the 10,000,000th car at the Detroit works on the 4th ultimo. The development of the Ford business in this country has been a factor of considerable industrial importance, and, since the Ford Motor Company (England) Limited, was formed, with works at Manchester, in 1911, the annual sales of the Company's cars and trucks have steadily increased from 1,485 at first to 40,000 at the present time. These figures, it should be noted, do not include the production for export to several Continental countries which are dependent on the English Company for many chassis and body parts. Several new models, including a redesigned chassis with a lower frame, suited to British roads, have recently been produced, among them being a touring car in which 92 per cent. of the material used is of British manufacture. British labour is employed almost exclusively at the Company's Manchester works, the proportion amounting to 99·79 per cent. These facts were mentioned by Mr. H. S. Jenkins, the managing director of the British Company, at a luncheon given at the Hotel Metropole on the 10th instant, preparatory to a statement relating to the future development of Ford industrial activities in this country.

Mr. Jenkins stated that the British Company had recently acquired a site of 307 acres at Dagenham in Essex, with a view to establishing there a works capable of employing 10,000 hands and of producing 500 cars a day. The site, which consists partly of agriculture and partly of reclaimed land, lies between the main London–Southend road and the river, and has a water frontage of 2,200 ft. It is also traversed by the London, Midland & Scottish Railway, so that there are ample transport facilities. Its proximity to the large labour resources of the east end of London is another advantage from the industrial standpoint. When the site was purchased, we understand, it was the intention of the Company to proceed with the building operations without delay as it was anticipated that the present position in which the Ford car is placed by the horse-power tax would be adjusted; to some extent the development plans will be affected by the trend of legislation in this direction. Another factor affecting the situation is the abolition of the McKenna duties, which renders the manufacture of Ford cars in this country for the British market unprofitable, although it would hardly affect the continental market. A full discussion of the anomalies of the horse-power rating for the taxation of motor cars will be found on page 811 of our 110th volume and on page 4 of our 111th volume. We must refer our readers to these articles for information as to the application of the present system to the Ford car.

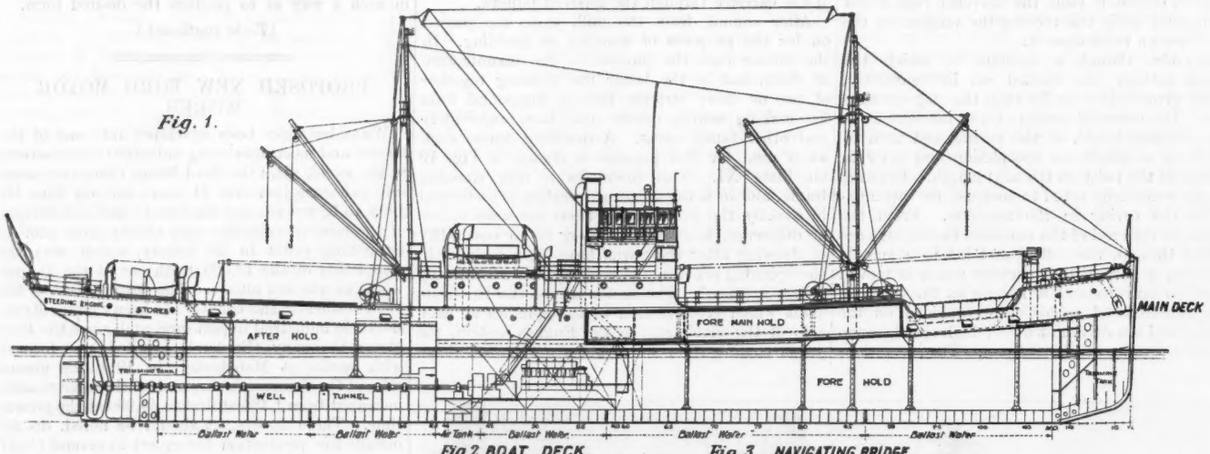
PULVERISED FUEL—CORRECTION.—With respect to our report, in last week's issue, of the discussion on Mr. L. C. Harvey's paper at the World Power Conference, we are asked by Mr. Harvey to correct the statement that it was owing to his suggestion that Mr. John Anderson had adopted pulverised fuel at Milwaukee. Mr. Anderson had been using pulverised coal for about two years before Mr. Harvey visited Milwaukee in 1918.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that the production of pig-iron in June amounted to 607,800 tons compared with 650,900 tons in May and 692,900 tons in June, 1923. The number of furnaces in blast at the end of the month was 185, a decrease of 6 since the beginning of the month and the lowest number in blast since January, 1923. The output of steel ingots and castings amounted to 651,500 tons, compared with 809,700 tons in May and 767,700 tons in June, 1923.

THE SHIP "VULCAN" WITH DIESEL-HYDRAULIC DRIVE.

CONSTRUCTED BY THE VULCAN-WERKE, ENGINEERS, HAMBURG.

Fig. 1.



LENGTH P.P.	70.00m	= 229'-8"
BEAM	10.98 "	= 36'-0¼"
HEIGHT MAIN DECK	5.195 "	= 17'-0½"
HEIGHT QUARTER DECK	6.395 "	= 21'-0"
DRAFT LADEN	4.960 "	= 16'-3¼"
S.H.P.	620	S.H.P.
SPEED	9·5	KNOTS

Fig. 2. BOAT DECK

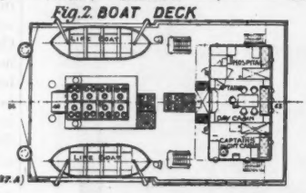


Fig. 3. NAVIGATING BRIDGE

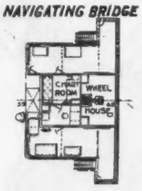


Fig. 4. POOP DECK — *BRIDGE DECK*

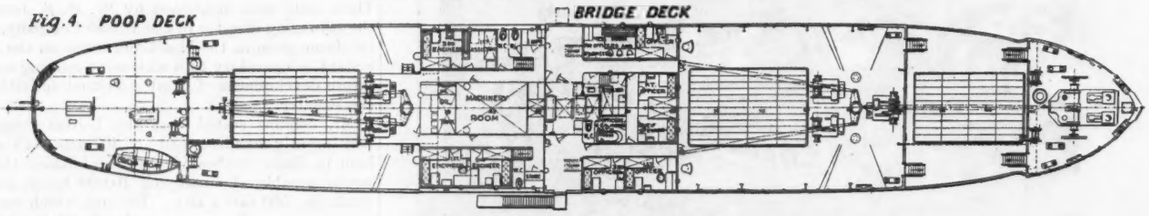


Fig. 5. MAIN DECK

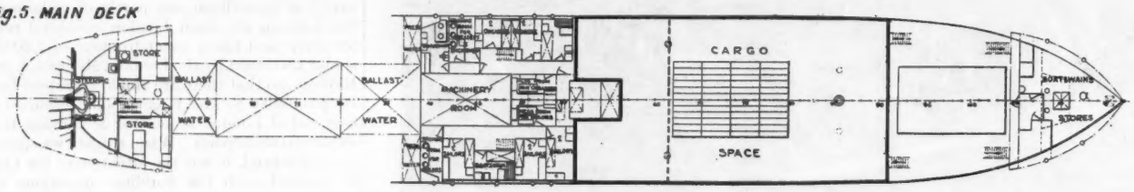
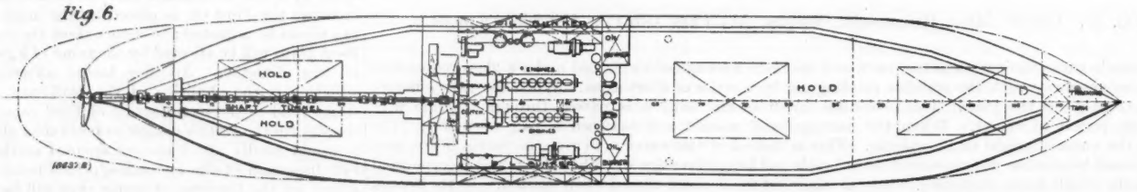


Fig. 6.



THE VULCAN DIESEL-HYDRAULIC DRIVE.

THERE would not seem at the present time to be any limit to the number of alternatives, in respect of type of machinery, which can be applied to the propulsion of vessels, and the subject in this article, together with the accompanying illustrations, is one of the latest systems which has been developed, with a view to minimising the space occupied by, and the weight of, marine internal-combustion machinery, and in order to make possible and convenient installations of powers up to approximately 50,000 shaft horse-power on two screws, for the largest class of passenger liners.

Briefly, the essentials of the system to which we are referring, comprise relatively high-speed Diesel engines, connected by means of oil-filled clutches to pinion shafts, geared (one on each side of a gear wheel) to the propeller shaft which runs at the speed of revolution most suitable to permit of the maximum propulsive efficiency.

The ship, the Vulcan, of 2,000 tons deadweight, to which the system has been applied, is illustrated in Figs. 1 to 6 above, while the machinery is shown in Figs. 7 and 8 on the opposite page. The vessel, which has been built at the Vulcan-Werke, Hamburg and Stettin, is 229 ft. 8 in. between perpendiculars, 36 ft. 0¼ in. beam, height to the main deck 17 ft. 0½ in., draught 16 ft. 3¼ in., and with machinery of 620 shaft horse-power, develops 9·5 knots. The clutch arrangements are built under the Vulcan-Föttinger patents.

The Diesel engines utilised in this case are not specially designed for this service, but are two submarine-type engines each of six cylinders, of the trunk piston type with air injection of the fuel, working on the four-stroke cycle, which were available to try out this new principle. The cylinder diameters are 330 mm. (13 in.), and the stroke is 350 mm. (13·8 in.). The engines have been rated down from 350-400 r.p.m. to 300 revolutions, and together develop normally at sea about 570 brake horse-power, at which power the ship has a speed of 9½ knots in service. Each engine is fitted with the usual air starting arrangements, but is non-reversible. The after end of each of the two engine crankshafts is coupled rigidly to the after end of the ahead hydraulic clutch into which oil is introduced, causing the driven member forward of the driving member to rotate, and to drive the pinion gearing with the gear wheel on the propeller shaft. Exactly the same system applies to both sides.

At the forward end of the pinions, the astern clutches are located. The emptying of the ahead clutch of oil and the filling of the astern clutch causes reversal. These clutches are exactly similar in principle to the well-known Föttinger transformer, except that oil is used instead of water, and no speed reduction is effected through the medium of this apparatus. As with the Föttinger transformer, reversal is achieved by the interposition between the driving and the driven member of fixed vanes which suitably direct the flow of the oil to give the reverse rotation. The axial pressure of the oil is utilised to balance the thrust of the single helical mechanical gearing, which is of normal design, incorporating with the forward bearing of the main gear wheel in the gear-case a Michell thrust block. The oil used in the clutches serves to lubricate the gears.

The question of the efficiency of the transmission of power by these means may well be raised. Very

THE SHIP "VULCAN" WITH DIESEL-HYDRAULIC DRIVE.

CONSTRUCTED BY THE VULCAN-WERKE, ENGINEERS, HAMBURG.

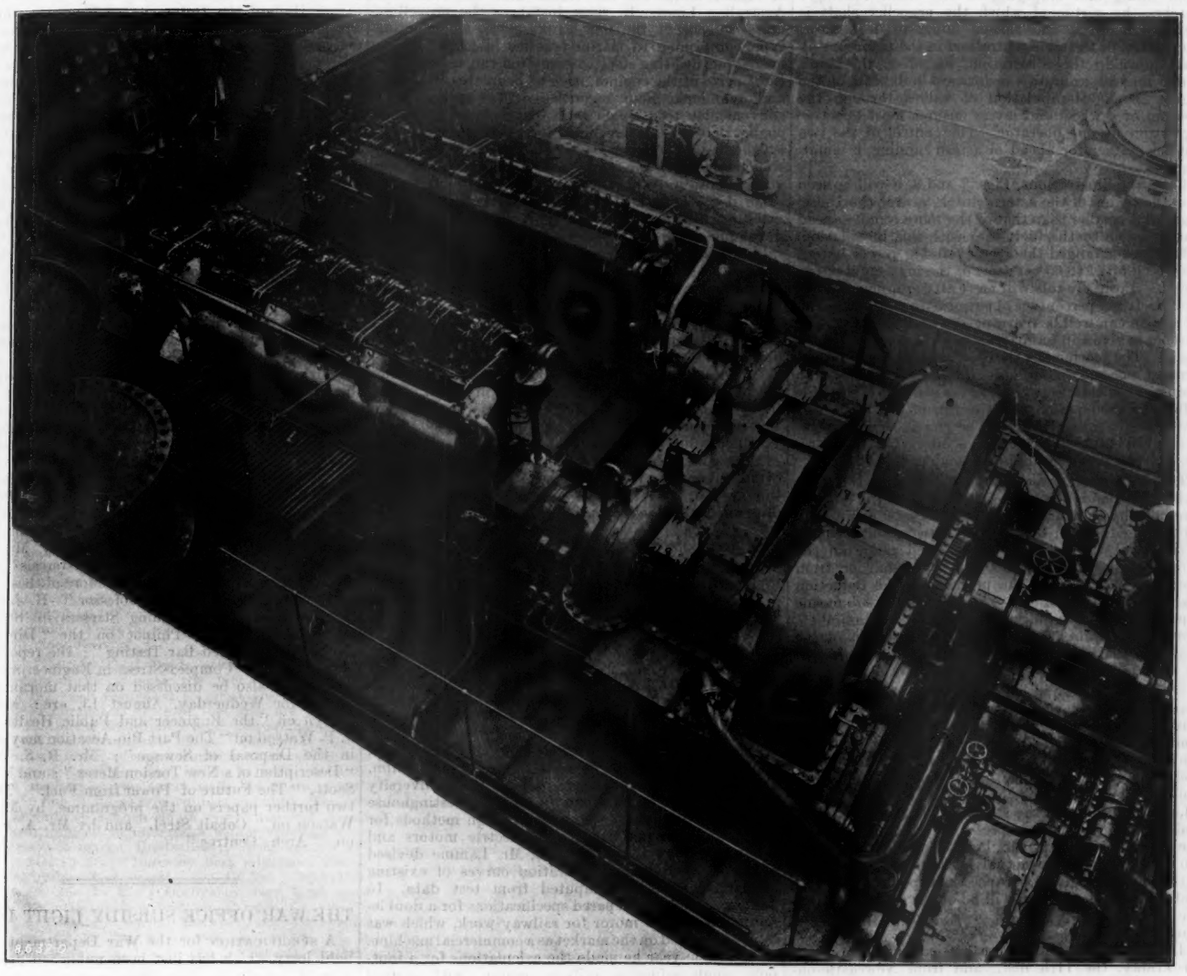
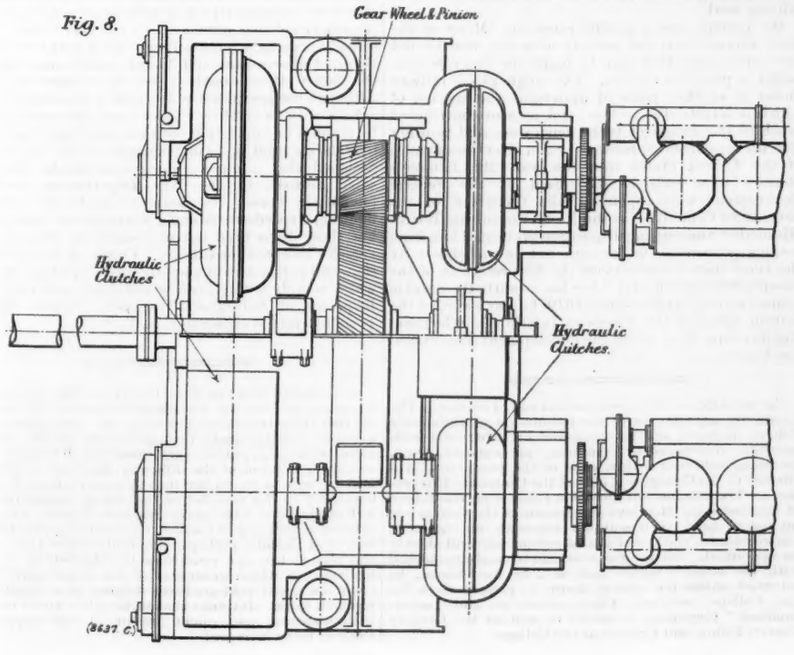


FIG. 7. VIEW OF ENGINES AND GEAR IN WORKSHOPS.

Fig. 8.



accurate tests were carried out in the engine builder's works, and it is claimed that ahead the efficiency is 98·5 per cent. That some slip must take place is obvious, since the oil is used to form a flexible coupling between the reciprocating Diesel engine with its uneven turning moment and the single reduction gear. As already indicated, the drive from the main engine is through a shaft running inside the driven helical pinion, and the relative movement between these two shafts is a measure of the slip. This relative rotation is stated to be of the order of 1½ r.p.m. Furthermore, the oil in the clutch system would become heated and positive cooling means would be required, if any substantial portion of the input power were wasted in friction. The rise in temperature from starting to the attainment of a steady temperature is from 30 deg. Celsius to 50 deg. Celsius. The efficiency of the gear when running astern, due to the reversal of direction of the shaft, which must be achieved by changing the direction of the flow of the oil by the blades of the transformer, is somewhat lower than for ahead rotation, 97 per cent. being claimed. The evidence of the relative rotation of the two shafts, and of the small rise in temperature of the oil, as already mentioned, disproves any fears of large or even considerable losses. In any case, this loss will be minimised, if not completely negatived, by the increase in propulsive efficiency due to the greater efficiency of the considerably lower speed propeller.

For circulating the oil through the clutches in normal running, a small pump driven by an electric motor is used. The power taken by this pump is ¼ h.p. When manœuvring, however, to effect rapid reversals a more powerful pump must be used. The manner in which this is worked out is extremely neat. A centrifugal pump is gear driven by a vertical

shaft from the main shaft and a very small Föttinger clutch is interposed in the drive of this small pump, so that filling and emptying this small Föttinger clutch throws this pump in and out of action for the rapid filling and emptying of the main Föttinger clutches, by virtue of which the propeller shaft is stopped, reversed and slowed down to dead slow. The control of the oil is centralised in the manœuvring gear shown in the illustration, Fig. 7 on the ship's centre line adjacent to the forward bulkhead of the engine room. Manipulation of valves through the medium of a wheel and levers ensures most effective regulation by one operator. The control of the two clutches, either for ahead or astern running, is simultaneous.

From the illustrations, Figs. 7 and 8, it will be seen that the casing of the astern clutch, nearer the Diesel engines, is smaller than that of the more remote ahead clutches, due to the fact, that with this installation, it has been arranged that the available power astern shall be limited to 65 per cent. of the maximum power ahead. Probably this will meet all requirements, but should a larger percentage of power astern be demanded, the design can well be rearranged with larger reversing clutches to give approximately the same power astern as ahead. The gearing and the clutches are built together, forming one complete unit in a common cast-iron casing. The clutches are also of cast iron. The single helical toothed pinion and the rim of the main gear wheel are of special steel. The rim is shrunk on to a cast-iron body. The teeth, it is interesting to record, are cut on a precision milling machine.

The Diesel engines are kept running all the time and speed regulation of the propeller shaft is effected generally by slowing down the two Diesel engines by controlling the fuel delivery to both simultaneously in the usual way. This gives a speed range on the Diesel engines of from 300 to 90 r.p.m., or from over 83 to 25 r.p.m. of the propeller. The reduction gear has a ratio of 3·62 to 1. These particular submarine type engines have not a high range of flexibility. Nor is this required, because further reduction of the propeller shaft down to 10 r.p.m. can be achieved by control of the oil supply to the clutches.

Should it be desired at any time to stop one of the two main engines, all that is necessary is to empty the driving clutch and shut off the fuel from that engine. Similarly either engine may be started up by opening the compression cocks in the cylinders, turning on the fuel and admitting lubricating oil to the clutch, when the other engine, acting through the gearing and the oil in the clutch, sets the stationary engine in motion, and on the cylinder compression cocks being closed the engine picks up the load and runs normally. No description of the actual Diesel engine employed with this ship is given, because the type is well known and the leading features will be observed clearly from the reproduction, Fig. 7, of a photograph of the propelling plant.

Demonstration trials were carried out from Leith on Friday, the 11th inst., and from Newcastle-on-Tyne on Wednesday, the 16th inst., and the manœuvres and running of the installation were in accordance with the principles of the design as described. The ease of control of the various small oil valves, stopping, starting and slowing down of the propeller shaft, whilst the Diesel engines were running at constant speed, as controlled by the engine governor, was very marked. The absence of reversing gear on these engines makes for desirable simplicity. There was only one starting air bottle of very modest dimensions for each main engine, in addition to the usual blast bottle. From the illustrations given, it will readily be appreciated that the whole installation is exceedingly compact, and that the headroom required by these small and relatively high-speed engines is low. A careful examination of the running of the gear gave evidence, through lack of noise, hammer, or vibration, of the efficacy of the oil clutches in damping out the inevitable irregularities of turning moment of the Diesel engine. The action of the oil, in addition, will serve to synchronise the two prime movers. Torque indicators are fitted and prove that the turning moment of the propeller shaft is as even as with a rotary engine. This proof has, it is stated, been recognised by the Registration Societies, and the sizes of the shafting abaft the oil clutches are only required to be the same as are called for in the case of geared turbine drives.

Whilst the clutches and gearing may appear from the illustrations of this particular installation to be almost disproportionately large, it must be stated that, with much larger powered plants, the increase in size of the gearing and the clutches would not be proportional to the greater power. With this system very large powers can be applied to single screws without involving the adoption of any new principle in the prime mover or of such large sizes of units as to constitute an experimental factor. Space and weight would be saved, and what is of particular importance with passenger vessels, head room would be also economised.

Installations are being constructed by the Vulcan Company for two 10,000-ton d.w. single-screw vessels of 4,000 b.h.p. for the Hansa and the Hamburg Australian Lines. In these instances the propelling units will be of the four-stroke cycle, single-acting type, conforming to marine practice in having cross-heads, but utilising steel castings for the main structural parts of the engines, such as bedplates, columns, and cylinders. Four engines can be applied very conveniently to a single shaft. The type of Diesel engine that may be developed for this particular duty is not rigidly fixed. Owing to the multiplicity of similar sets and the great ease of disconnection for adjustment, it is not necessary to move with the same degree of caution and consideration as with machines direct coupled to the propeller. Interesting developments in the type of prime mover itself are taking place in Germany, and experimental work in a large scale is in progress. This system lends itself to the realisation of the fullest advantage being taken of these developments.

The m.s. Vulcan is equipped with the most modern plant in all respects. All the auxiliaries are electrically driven. Current is generated by two small 4-stroke cycle Diesel generating sets of 60 b.h.p. each, running at 400 r.p.m. and working with solid injection of the fuel. To one, a small auxiliary compressor for charging the reservoirs of the main engine is coupled by a Föttinger clutch.

Messrs. British Föttinger Marine Transformers, 195, Strand, London, W.C., are the British licensees for the system, and to them we are indebted for the illustrations of the Vulcan, reproduced above.

THE LATE MR. B. G. LAMME.

THE news of the death of Mr. Benjamin G. Lamme, for more than twenty years the chief engineer of the Westinghouse Electric and Manufacturing Company of East Pittsburg, which reached this country during the World Power Conference, caused deep regret not only among the large number of his fellow-citizens who are at present in this country, but equally among engineers from all parts of the world. His work in the field of electric traction was well known, for he had been associated with its development from very early days, and many important inventions are due to him. Mr. Lamme graduated at the Ohio State University in 1882. He entered the test room of the Westinghouse Company on May 1, 1889, and although methods for calculating the performance of electric motors and generators were then unknown, Mr. Lamme devised a means whereby the saturation curves of existing machines could be computed from test data. In January, 1890, he prepared specifications for a double-reduction electric motor for railway work, which was built and placed on the market as a commercial machine. In the same year he made the calculations for a four-pole single-reduction railway motor, with slotted armature, machine-wound coils and a two-circuit wave winding—a design which is still largely used in railway work.

Mr. Lamme was a prolific inventor. Many of the early rotary converter patents were his, and he did more than any other man to make the 60-cycle converter a practical success. The single-phase railway motor is another piece of apparatus the success of which is largely due to him, and he also contributed much to the design of turbo generators and to other alternating-current apparatus. Soon after the entrance of the United States into the war, Mr. Lamme's abilities were publicly recognised by the Federal Government who appointed him Chairman of the Inventions Committee of the Naval Consulting Board. His modest and retiring disposition prevented him from seeking prominence or honours, but he was chosen by the Ohio State University as the first recipient of the Joseph Sullivant medal "for his admittedly notable achievements," and in June, 1919, he was awarded the Edison Medal of the American Institute of Electrical Engineers for his work in the development of electrical machinery.

CENTENARY OF UNIVERSITY COLLEGE, LONDON.—The hundredth anniversary of the foundation of University College, London, will be celebrated in 1926. Materials (records, reminiscences, pictures, photographs, &c.), are being collected with a view to the production of a History of the College as a part of the Centenary Celebrations. The volume will include a chapter on the School of Engineering. Members and friends of the College are invited to send such suitable materials as they can contribute, for the use of the historian, who will shortly be appointed. All documents should be carefully marked with the owner's names and will, in due course, be returned unless the owners desire to present them for the College archives. Communications and parcels (marked "Centenary") should be sent to Mr. Gregory Foster, Fellow and Provost at the College.

THE TORONTO MEETING OF THE BRITISH ASSOCIATION, SECTION G.

THE inaugural meeting of the Association will be held on Wednesday, August 6, in the Convocation Hall of the University of Toronto, when the President Elect, Major-General Sir David Bruce, will deliver his address on "Prevention of Disease." Sectional meetings will take place on six days of the full week, Thursday, August 7, to Wednesday, August 13. So far as settled the programme of Section G, Engineering, is the following: On the Thursday morning Professor G. W. O. Howe will deliver his address on "One Hundred Years of Electrical Engineering." Papers by Sir Henry Thornton, on "Railway Transportation in Canada," and by Lieut.-Colonel H. S. Lamb, "Engineering Problems on the Great Lakes," will follow; the section will not meet in the afternoon. The papers for Friday morning are by Mr. J. B. Challies on "The Water-Powers of Canada," by Mr. F. A. Gaby on "The Hydro-electric Power Commission of Canada," and by Mr. R. S. Lea on "The Development of the St. Lawrence for Power and Navigation"; in the afternoon the Section will be joined by Section A (Mathematical and Physical Science) in a discussion on "Optical Study of the Elasticity of Materials." Section G will not meet on Saturday. On Monday papers on stress and testing will be read by Professors H. S. Moore and T. M. Jasper on "Evidence for the Existence of an Endurance Limit in Metals and its Determination"; by Professor C. F. Jenkin on the "Work of the Fatigue Panel of the Aeronautical Research Committee"; by Professor F. C. Lea on the "Effect of High Temperature on Range of Repetition Stress"; by Professor B. P. Haigh on "A Large Mechanic Fatigue Tester"; by Messrs. H. F. Gough and H. J. Tapsell on "Some Comparative Fatigue Tests"; and by Mr. C. E. Stromeyer on "Torsion Fatigue Hysteresis"; there are no papers for the afternoon. More of these papers will follow on Tuesday, by Professor T. H. Jasper on "Measurement of Quenching Stresses in Steel," and by Professor H. P. Philpot on the "Dimensional Problem in Notched-Bar Testing"; the report of the Committee on "Complex Stress in Engineering Materials" will also be discussed on that morning. The papers for Wednesday, August 13, are: Mr. F. A. Dallyn on "the Engineer and Public Health"; Mr. J. P. Watson on "The Part Bio-Aeration may yet play in the Disposal of Sewage"; Mr. R. S. Whipple, "Description of a New Torsion Meter"; and Mr. E. K. Scott, "The Future of Power from Fuel." There are two further papers on the programme, by Mr. E. A. Watson on "Cobalt Steel," and by Mr. A. E. Wynn on "Arch Centres."

THE WAR OFFICE SUBSIDY LIGHT LORRY.

A SPECIFICATION for the War Department subsidy light lorry which has just been published defines the type of vehicle the War Office is enrolling under the subsidy scheme; and it is officially stated that it is the intention of the Department to utilise this specification not only in respect of vehicles subsidised, but in respect of vehicles purchased by the War Office. The subsidy-type light lorry will now differ very little from the light char-a-banc and 30-cwt. and 2-ton lorries of the latest British-made types in commercial use. Although the specification describes a pneumatic-tyred vehicle with 38 or 34 by 7 giant tyres, the subsidy may be granted in connection with vehicles which normally operate on solid or twin pneumatic tyres, but are so designed that a quick change-over can be effected, when desired, to the War Department standard pneumatic tyres. Provision is made for electric lighting, a speedometer and a power-driven tyre pump, but these items need not necessarily be fitted to the vehicles accepted for subsidy. Copies of the specification, and particulars of manufacturers building vehicles which comply with it, can be obtained from the Chief Inspector of Subsidised Transport, Caxton House, Tothill-street, Westminster, S.W. 1.

INDUSTRIAL RESEARCH IN CANADA.—The problem of financing an Institute for scientific research in Canada, so that the Dominion industry can keep pace with scientific developments throughout the world, is once more before the public, says *Canadian Machinery*. In seeking a solution of the difficulty, the journal adds, it may be well to remember that Germany attained world leadership in this field before the war by rewarding with a Hohenzollern title every research worker who discovered anything worth while. One contemporary further says that Canada, perhaps, cannot do better than adopt this plan to her own conditions by establishing such an institute, in which graduates of Canadian universities could be given post-graduate degrees as a reward for research work. It thinks that such a plan would involve little expense, and might result in the supply of workers being increased.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Further striking evidence of the continued shrinkage in the coal export trade of South Yorkshire *via* Hull is afforded by the official traffic returns issued this week for the period ending June. The total received at the port from collieries during June declined by 283,000 tons as compared with the same month last year, while, for the first half of this year, the total tonnage sent to Hull for all purposes dropped, as compared with the corresponding six months of last year, by no less than 1,139,000 tons. The main cause was the contraction in export buying. Shipments for the six months were down 968,000 tons, including a drop of 88,318 tons during June last, in comparison with the January to June period of 1923. The biggest fall in purchases was with France and Germany. A notable feature was that Sweden, in comparison with the preceding year, increased her six months' takings from 141,000 tons to 220,000 tons.

Iron and Steel.—The week's developments reveal little sign of improvement in the heavy iron and steel trades. Rather is the general movement in the downward direction. Prices for all classes of iron and steel (with the exception, perhaps, of bar iron, which, owing to railway demands, has appreciated) were rarely lower, but the discouraging fact remains that, in comparison with the quotations offered by foreign competitors, they are unattractive to potential buyers abroad, on whom the local heavy trades mainly rely. On the whole there is a general decline in purchases, with a corresponding contraction in outputs. To some extent the latter is accounted for by the fact that midsummer stocktaking operations at some of the big works have not yet been completed. Order books, however, give little promise of improved conditions in the near future. Bank experts, in reviewing the position, agree that the general state of affairs is quieter than at any period during the present year, and point out that the majority of the open hearth furnaces in the district are idle. Plants manufacturing the cheaper classes of steel, soft and basic, display a sagging tendency, though steel sheets are in request, the mills concerned being actively engaged, while forward bookings are good. Business in high-speed steel has declined, but tool makers are taking a large tonnage of crucible steel. There is also a shrinkage in wire and wire rope manufacture.

South Yorkshire Coal Trade.—Collieries are carrying substantial stocks, despite the fact that short-time working has been instituted to offset the general contraction in purchases. Pits in this area are badly hit by the continued slump in export requirements. Inquiries are fairly numerous from Continental buyers, but relatively few of these are resulting in actual business. The home demand for best steams is only moderate. Washed slacks keep up fairly well, but there is little activity in fine qualities or in cobbles and nuts. The condition of railway sidings shows few house-coal buyers have been induced to undertake winter stocking while conditions are easy. Quotations:—Best hand-picked branch, 34*s.* to 35*s.*; Barnsley best Silkstone, 28*s.* to 29*s.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house, 25*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 23*s.* 6*d*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is still very quiet, but some expansion of inquiry is reported, and actual transactions have been on a slightly better scale. The statistical situation is stated to be by no means unsatisfactory, as the bulk of the iron stored at makers' yards is understood to have been sold. Present production, however, is rather considerably in excess of current demand, and stocks threaten to increase unless sales become heavier or output is curtailed. Quotations are easy and contracts have been made at below recognised market figures. No. 1 is still scarce but customers claim they can place orders at 92*s.* No. 3 g.m.b. is obtainable at 87*s.*; No. 4 foundry is quoted 86*s.*; and No. 4 forge is put at 85*s.* All the foregoing quotations are f.o.b. Tees.

Hematite.—Two furnaces have just been re-kindled on hematite, but another two are expected to go out of blast, so that the quantity being produced promises to be unaltered. Sales in this branch are slow, and manufacturers are ready enough to make price concessions to secure orders. Though some firms hold out for 96*s.* for Nos. 1, 2 and 3, purchases have been made at 95*s.* 6*d.*, and indeed less has been accepted. No. 1 is put at 6*d.* above mixed numbers.

Foreign Ore.—There is little or nothing doing in imported ore, and definite quotations are not easily obtained. Sellers still base market rates on best rubio at 23*s.* c.i.f. Tees.

Blast-furnace Coke.—There is a rather steadier feeling in Durham blast-furnace coke, but sales are on a limited scale, customers showing little disposition to contract ahead. Good medium qualities are in the neighbourhood of 27*s.* delivered here.

Manufactured Iron and Steel.—Galvanised corrugated sheets (24 gauge) are very firm at 18*l.* 5*s.* and makers have full order books, but in nearly every other branch of manufactured iron and steel contracts are difficult to secure and prices are weak. Principal market quotations stand: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to Board of Trade returns, the quantity of coal shipped from the principal South Wales ports in June amounted to only 1,897,552 tons, compared with 2,261,355 tons in May, and with a monthly average of 2,457,297 tons in 1923. The f.o.b. value of the shipments, too, was reduced from 2,888,450*l.* in May to 2,378,405*l.* in June as compared with an average of 3,211,212*l.* per month last year. Compared with May there was thus a reduction of 363,803 tons in value and of 510,045*l.* in revenue in June while the average price per ton fell from 25*s.* 6½*d.* to 25*s.* 1*d.*, the lowest level reached this year. The fact that there were only 22 working days in June in consequence of the intervention of the Whitsun holidays was partly responsible for the decline, but the ten days' strike of railway shopmen and the resultant disorganisation of business was doubtless one of the chief factors for the adverse balance. Shipments of large coal were reduced from 1,479,835 tons to 1,223,712 tons and the average yield from 28*s.* 5*d.* to 28*s.* 2*d.* per ton, while small coal was lowered from 729,441 tons to 616,814 tons and the price from 19*s.* 11½*d.* to 19*s.* 3*d.* per ton but through coal exports were increased from 52,079 tons to 57,026 tons though the price was reduced from 21*s.* 2*d.* to 20*s.* per ton. Each of the ports shared in the retrogression, the returns for June being appended:—

From.	Volume.	Value.	Average.
	Tons.	£	Per ton. s. d.
Cardiff	1,118,556	1,363,983	24 4
Newport	350,475	435,308	24 10
Port Talbot	181,333	209,272	23 0
Swansea	247,188	369,842	30 0
Totals	1,897,552	2,378,405	25 1

In May the shipments from Cardiff amounted to 1,396,513 tons, from Newport to 408,337 tons, from Port Talbot to 192,145 tons, and from Swansea to 264,360 tons. The reduction that has taken place in prices is best illustrated by the following table showing the average prices per ton secured for steam coals shipped from Cardiff and Swansea in each month of this year:—

1924.	Cardiff.			Swansea.		
	Small. s. d.	Thr'gh. s. d.	Large. s. d.	Small. s. d.	Thro'gh s. d.	Large. s. d.
January ..	19 11	22 11	27 10	17 11	20 3	28 7
February ..	20 0	24 1	27 10	16 11	20 7	26 1
March ..	19 7	23 0	27 11	17 0	20 6	28 1
April ..	19 8	23 3	28 5	17 0	21 10	27 0
May	18 7	23 8	27 6	18 5	19 9	28 0
June	18 1	21 10	27 1	17 10	19 7	26 9

It will be observed that except for small and large steams shipped from Swansea, the average prices secured in June were the lowest for the year. Anthracite coal exported from Swansea in June totalled 184,825 tons, valued at 304,414*l.*, or 32*s.* 11*d.* per ton, which represented a reduction when compared with the preceding month, of 13,996 tons in volume, 34,204*l.* in value, and of 1*s.* 2*d.* per ton, large anthracite being reduced from 41*s.* 8*d.* to 41*s.* 4*d.* and small from 26*s.* to 23*s.* 11*d.* per ton. In the meantime the coal market remains in a state of depression, sufficient new business not being forthcoming to keep the collieries regularly employed. In the circumstances buyers can secure concessions on quoted prices. Best Admiralty large rules from 28*s.* to 29*s.*, with Monmouthshires from 23*s.* 6*d.* to 27*s.*, drys from 25*s.* to 26*s.* 6*d.*, and smalls from 13*s.* 6*d.* to 17*s.* 6*d.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been practically no change in the Scottish steel trade during the past week, and quiet conditions have ruled. A few extra lines were fixed up for despatch this week, in view of the possibility of the steel works having a longer holiday than usual, but beyond that there has actually been no pressure for delivery. The various works in the Glasgow area are closing down on Thursday, but the date of re-opening is a little uncertain and will largely depend on what may be fixed up during the next week or so. The orders now on the books for ship plates and sections do not amount to a heavy tonnage, but in most cases they have ensured the employment of a limited portion of the plant. The general inquiry of late has not been satisfactory, and a decided improvement would be most acceptable in view of the thin time through which the trade has passed. For black sheets the demand is still very good, and the lighter gauges are meeting with a ready sale, while the demand for galvanised qualities shows no falling-off. The bookings have recently been very heavy, and some producers are ensured steady running well on towards the end of the year. Prices are all keeping very steady, and to-day's quotations are as follows:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, ¼ in. to ½ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable-iron trade the past week has been about as dull as its predecessors. The booking of new business has been most difficult and inquiries have also been very poor. In the re-rolled steel branches the demand is likewise very slow. Prices keep steady, with "Crown" bars called 12*l.* 10*s.* per ton, delivered at Glasgow stations.

Scottish Pig-Iron Trade.—No improvement has taken place in the Scottish pig-iron demand over the week, and except for a few odd lots no pressure for delivery this week has been felt by producers. Stocks on hand are quite equal to the limited demand now being experienced. Prices are again rather weak and may be taken as under:—Hematite, 5*l.* per ton, delivered at the steelworks; foundry iron No. 1, 5*l.* 1*s.* 3*d.* per ton, and No. 3, 4*l.* 16*s.* 3*d.* per ton, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, July 12, amounted to 1,466 tons. Of that total, 1,308 tons went overseas and 158 tons went coastwise. For the corresponding week of last year the figures were 198 tons overseas and 60 tons coastwise, making a total shipment of 258 tons.

THE INSTITUTION OF GAS ENGINEERS.—A special meeting of the Institution will be held at 28, Grosvenor-gardens, Westminster, S.W.1, at 5 p.m. on Wednesday, the 23rd inst., for the purpose of submitting for confirmation a number of resolutions passed at the annual general meeting on June 24.

KELLY'S DIRECTORY OF MERCHANTS, MANUFACTURERS AND SHIPPERS.—A publication, which is of great benefit to manufacturers and merchants of all classes, whether exporters or importers, "Kelly's Directory of the Merchants, Manufacturers and Shippers of the World," reaches in the current year, the thirty-eighth annual edition. The work is in two volumes, and its price is 64*s.* post free. The first volume covers Europe, Asia, Africa, Central, North and South America, and the West Indies; whilst Volume II deals with Great Britain, her Colonies, Possessions and Dominions. In Volume I there is an alphabetical index to countries and towns and an alphabetical index to trades in English, giving the names of the towns in which the different trades are carried on. For facilitating search by foreign firms using the directory, alphabetical indexes are subjoined, giving the trade names in French, German, Spanish and Russian, with the English equivalents in every case. These four indexes are also intended to facilitate search in Volume II, which has a trade name index in English similar to that of Volume I. The two volumes have a total of about 5,000 pages, and give information, the publishers state, as to 20,000 foreign and colonial cities and towns, the trade descriptions numbering over 1,500,000. The work is printed and published by Messrs. Kelly's Directories, Limited, 168, Strand, W.C.2.

CONTRACTS.—The Lancashire Dynamo and Motor Company, Limited, Trafford Park, Manchester, state that they have received the following orders:—From the Swansea Corporation, for the whole of the electrical equipment for coal conveying plant, in the new extensions to their electricity works. The order includes motors driving electric truck tipplers, coal crushers, coal elevators and coal conveyors. All the motors are of the squirrel cage type, and the motors for driving the electric truck tipplers are of particular interest, because of the severe duty they have to contend with. These motors have to start against a load equal to two and a-half times full load torque and operate on a cycle of 2 minutes lift, 10 seconds stop, and 2 minutes run in the reverse direction.—From the Bedford Corporation, an order for a turbo alternator for coupling to an Allen turbine; it has a capacity of 4,415 k.v.a., 0·85 power factor, 6,600 volts, 50 cycles, 3 phase, 3,000 r.p.m.—From the London, Midland and Scottish Railway, Crewe, an order for a turbo-alternator, 1,875 k.v.a., 0·85 power factor, 6,600 volts, 50 cycles, 3 phase, 3,000 r.p.m., for coupling to a Belliss and Morcom turbine.—It is announced that the Bombay Port Trust have accepted the tender of Sir W. G. Armstrong, Whitworth & Co., Limited, for a steel floating caisson for the entrance to the Merewether Dry Dock, Bombay. The caisson will be constructed at the firm's Walker Shipyard, Newcastle-on-Tyne.—Messrs. Vickers, Limited, Hydro Electric Department, have received an order for two large water turbines from the Government of Ontario through its Hydro-Electric Power Commission. Each turbine will have an output of over 12,000-h.p., the height of fall being 72 ft. The power will be used for industrial purposes in and about Fort William and Port Arthur on the north shore of Lake Superior. These turbines will be built at Barrow-in-Furness, where Messrs. Vickers already have a substantial volume of such equipment under construction for various parts of the Empire.—The Latvian Ministry of National Defence has recently ordered from the Ateliers et Chantiers de la Loire, Nantes, and from the Chantiers et Ateliers Augustin Normand, Havre, two submarines and two mine sweepers.—Messrs. Meldrums, Limited, Timperley, state that they have recently received the following orders: For 38 sets of their forced draught and/or mechanical stokers; 20 plants for the disposal of dangerous refuse; five portable steam disinfectors; a "Meldrum" motor road sweeper-loader; several "Meldrum" motor-car trailers for camping purposes and various of their other apparatus for chemical plants. The plant is destined for use in a great variety of industries in this country and the Colonies.

7-METRE SOLAR SPECTROGRAPH FOR POULKOVO OBSERVATORY.

CONSTRUCTED BY SIR HOWARD GRUBB AND SONS, LIMITED, ST. ALBANS, HERTS.

(*For Description, see Page* 87.)

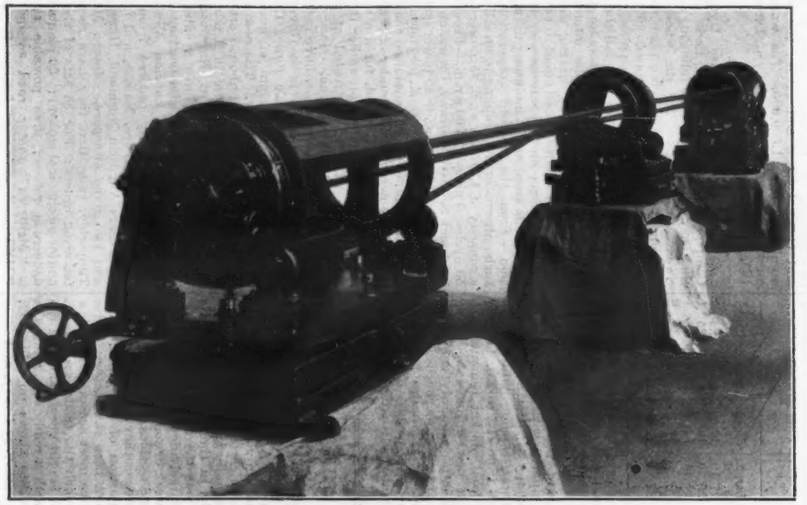


FIG. 11. MAIN PARTS OF SPECTROGRAPH SHOWING RELATIVE POSITIONS.

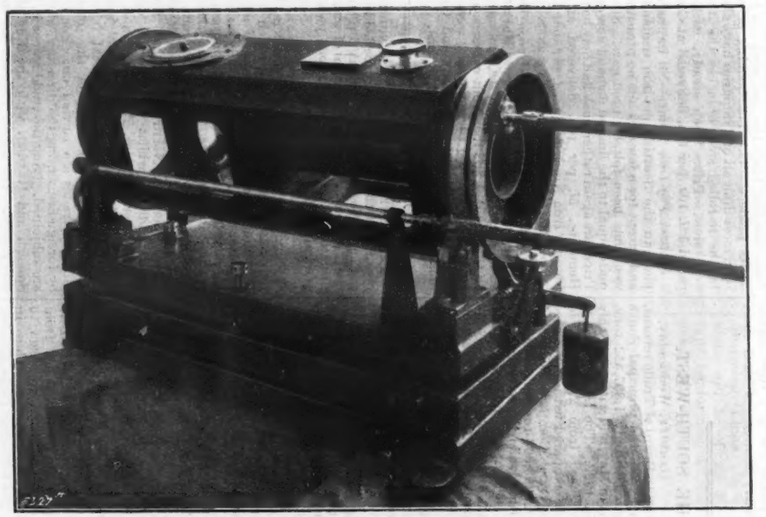


FIG. 13. REAR END OF INSTRUMENT CONTAINING COLLIMATING OBJECT GLASS AND GRATING.

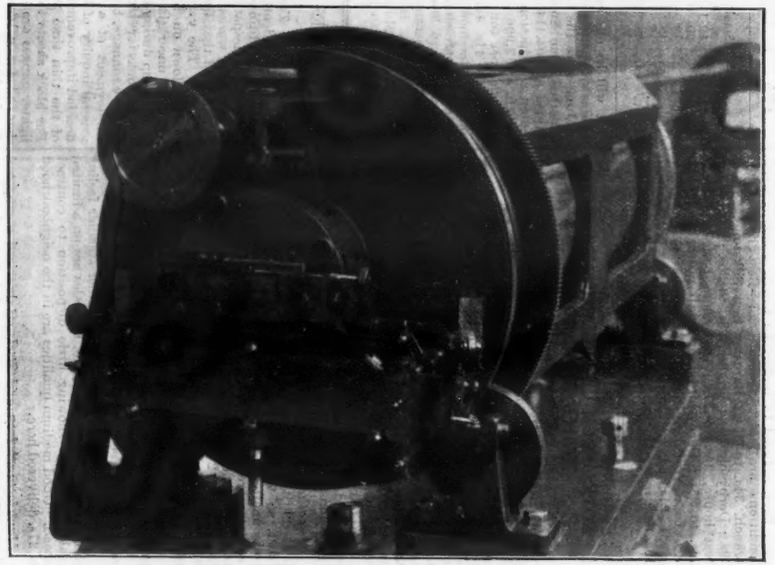


FIG. 12. FRONT END OF INSTRUMENT WITH SLIT AND PLATE HOLDER.

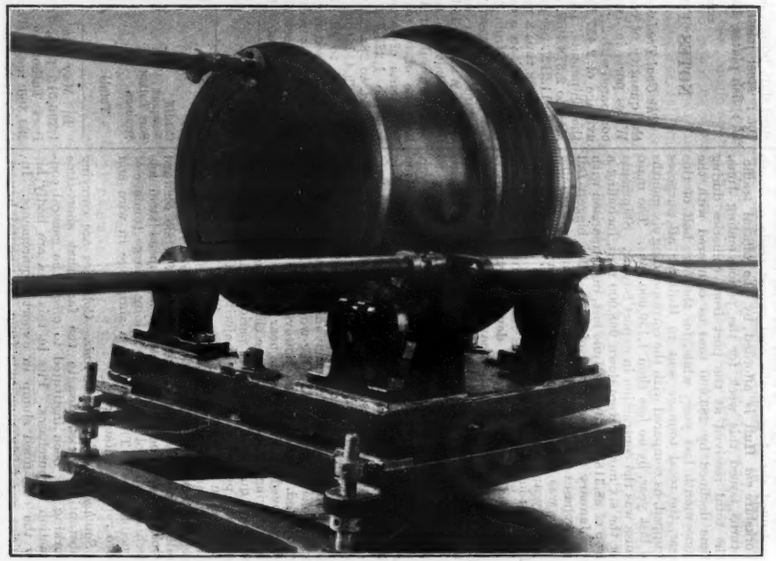


FIG. 14. CENTRAL PART OF INSTRUMENT CARRYING DIAPHRAGM.

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 89.)

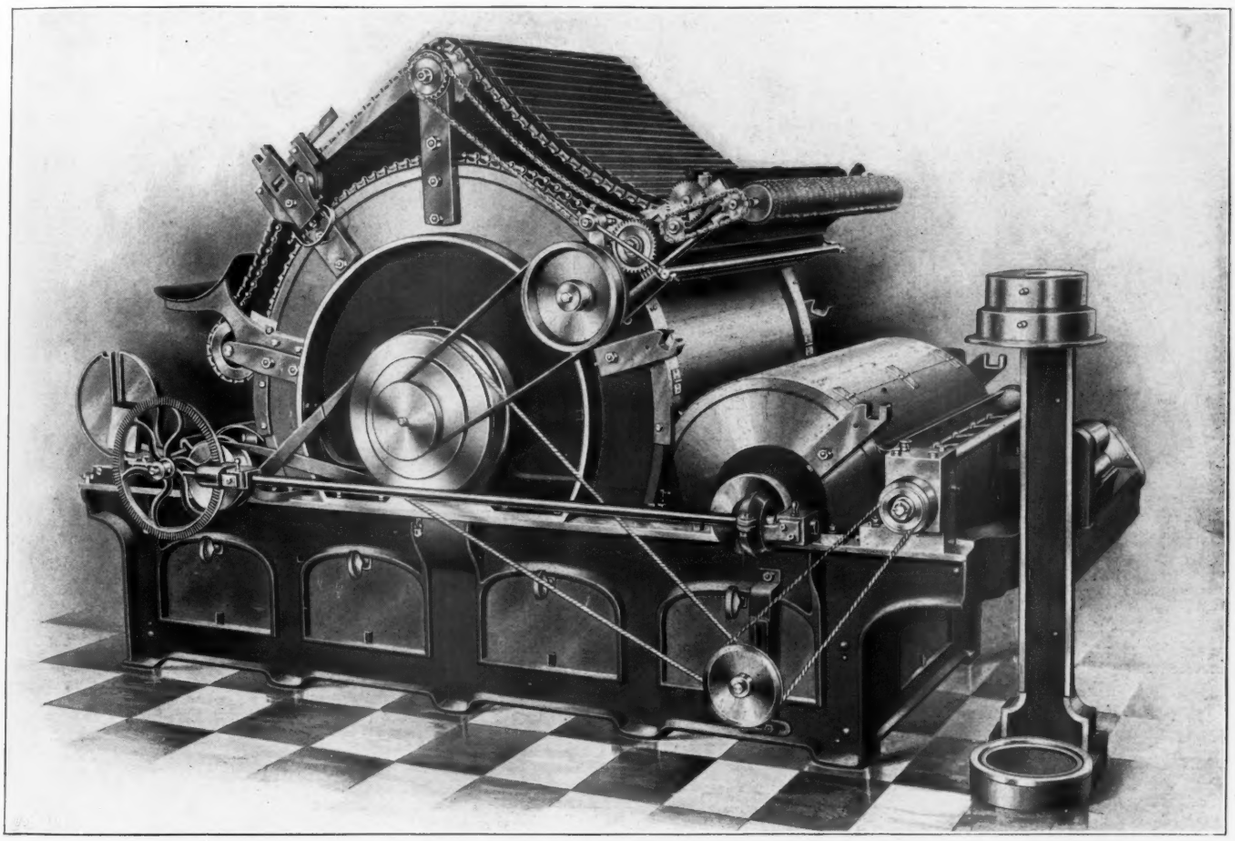


FIG. 14. CARDING ENGINE; MESSRS. ELIJAH ASHWORTH, MANCHESTER.

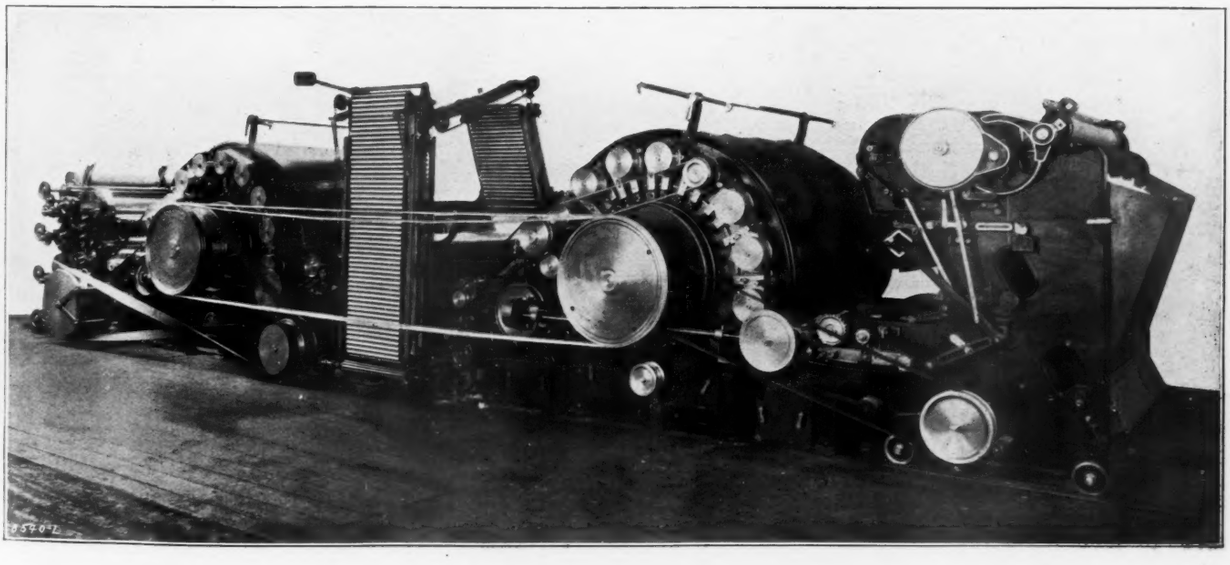


FIG. 15. CARDING ENGINE TO USE COTTON WASTE; MESSRS. WILLIAM TATHAM, LIMITED, ROCHDALE.

(*To face page* 90.)

FIG. 14. CENTRAL PART OF INSTRUMENT CARRYING DIAPHRAGM.

FIG. 12. FRONT END OF INSTRUMENT WITH SLIT AND PLATE HOLDER.

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 89.)

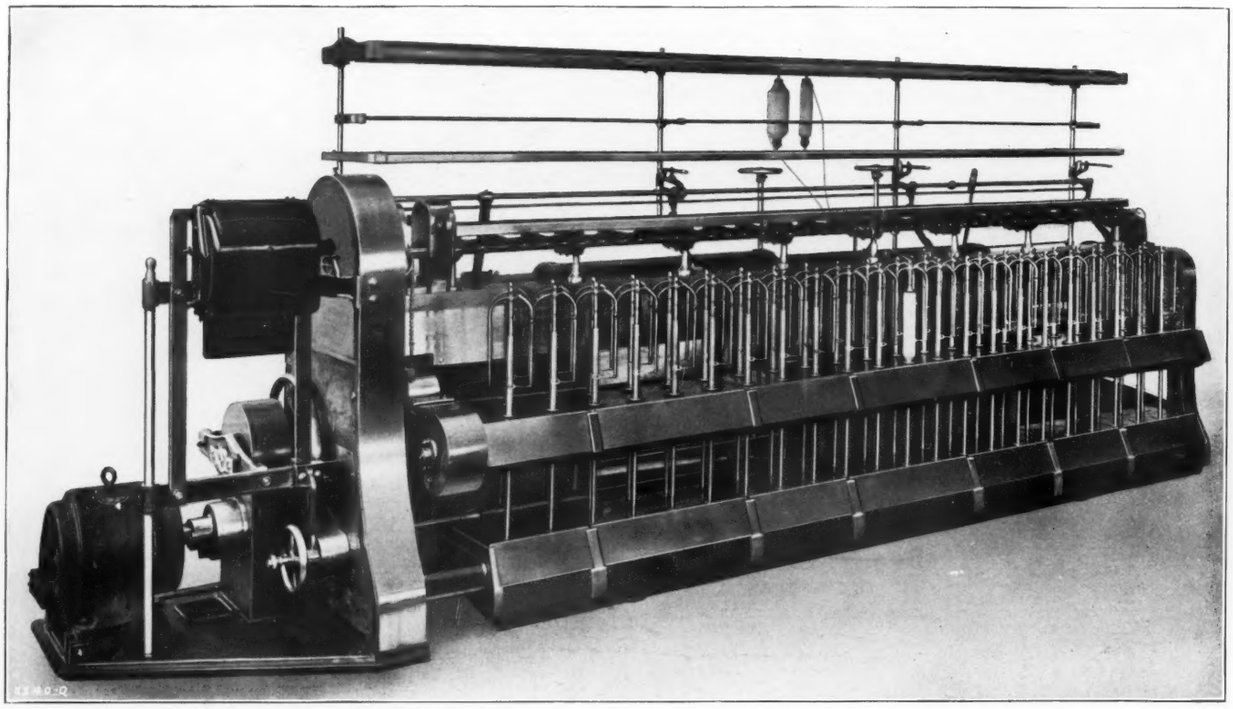


FIG. 17. SLUBBING, INTERMEDIATE AND ROVING FRAME; MESSRS. BROOKS AND DOXEY (1920) LIMITED, MANCHESTER.

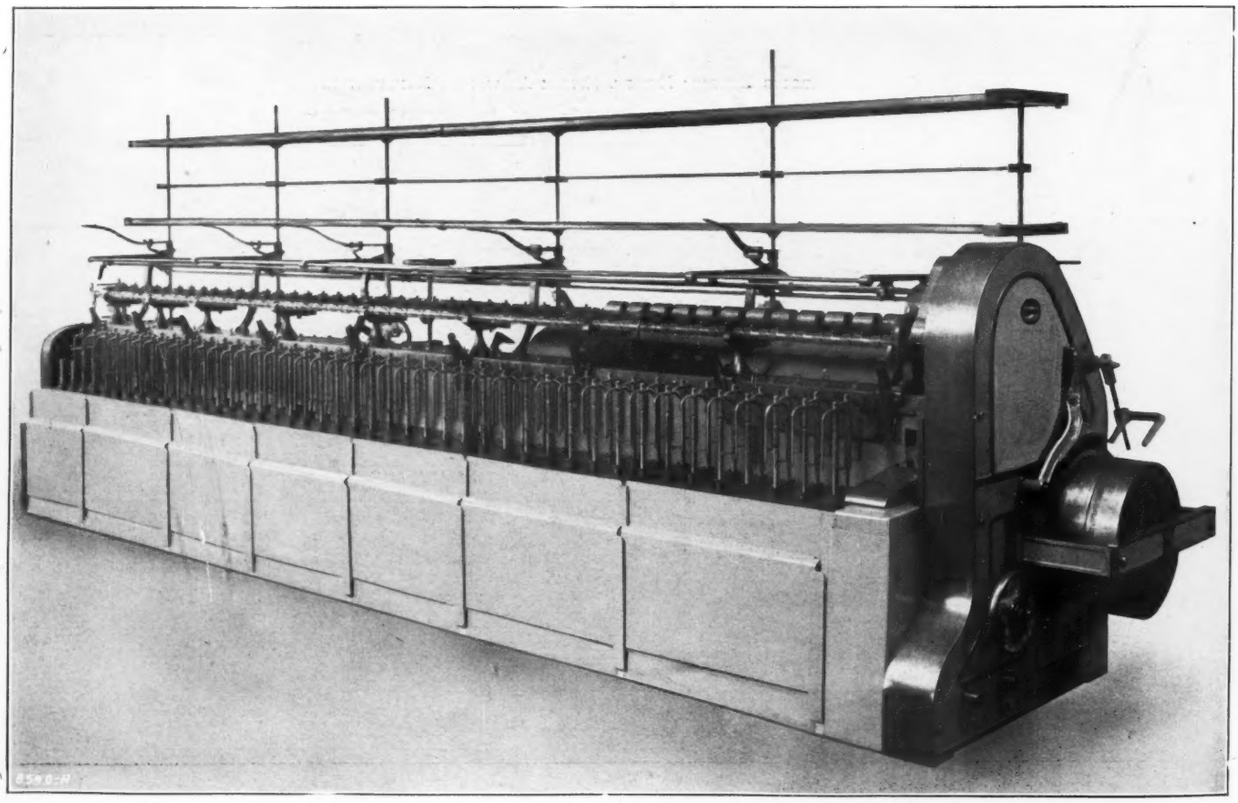


FIG. 18. FLYER FRAME; MESSRS. ASA LEES AND CO., LIMITED, OLDHAM.

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

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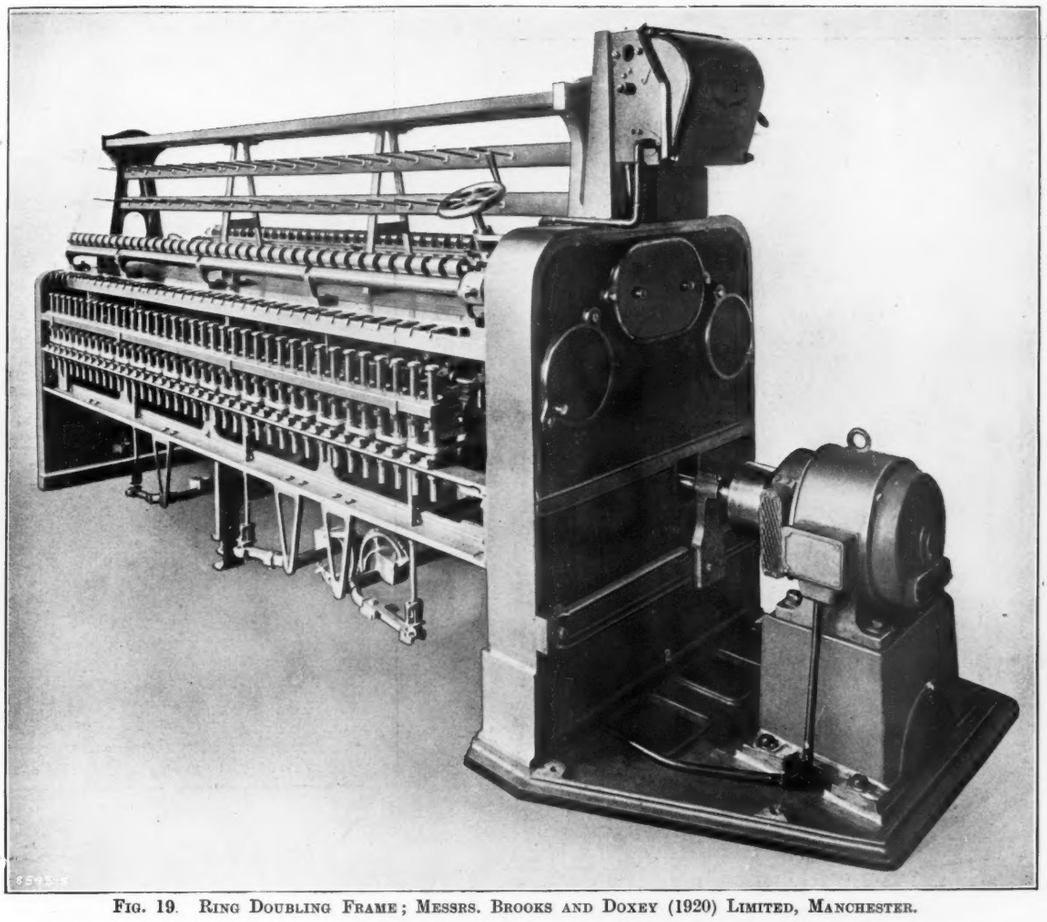

FIG. 19. RING DOUBLING FRAME; MESSRS. BROOKS AND DOXEY (1920) LIMITED, MANCHESTER.

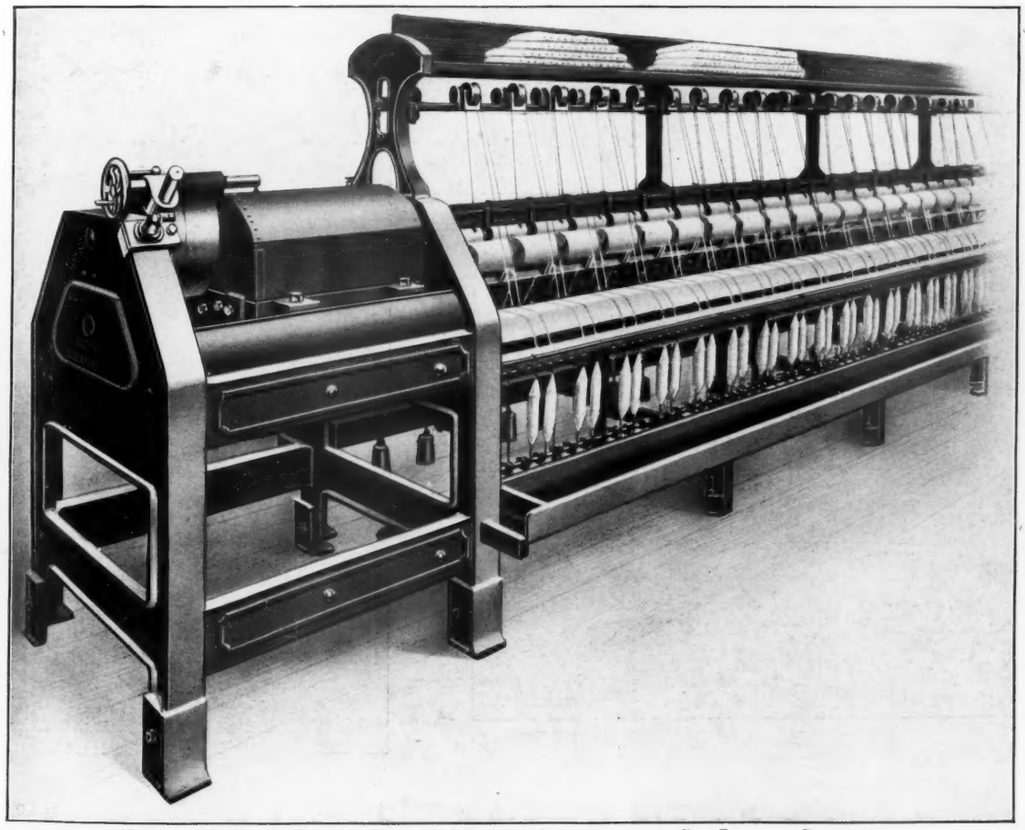

FIG. 20. WINDING FRAME. MESSRS. ARUNDEL, COULTHARD AND CO., LIMITED, STOCKPORT.

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. JOHN HETHERINGTON AND SONS, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 89.)

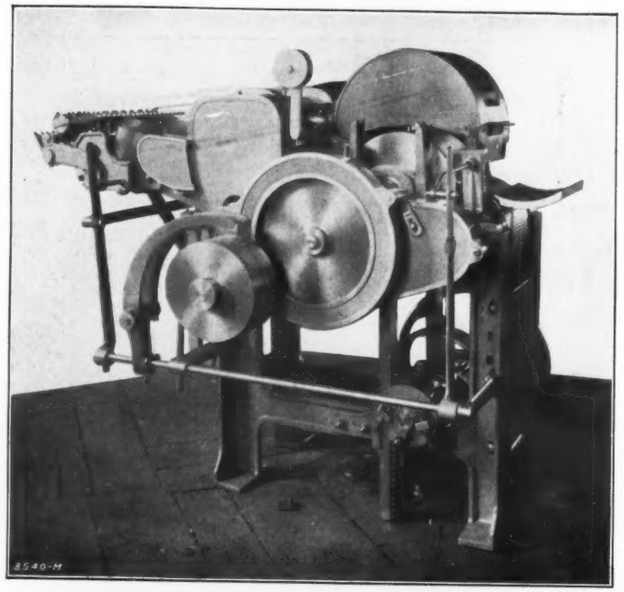

FIG. 21. SLIVER LAP MACHINE.

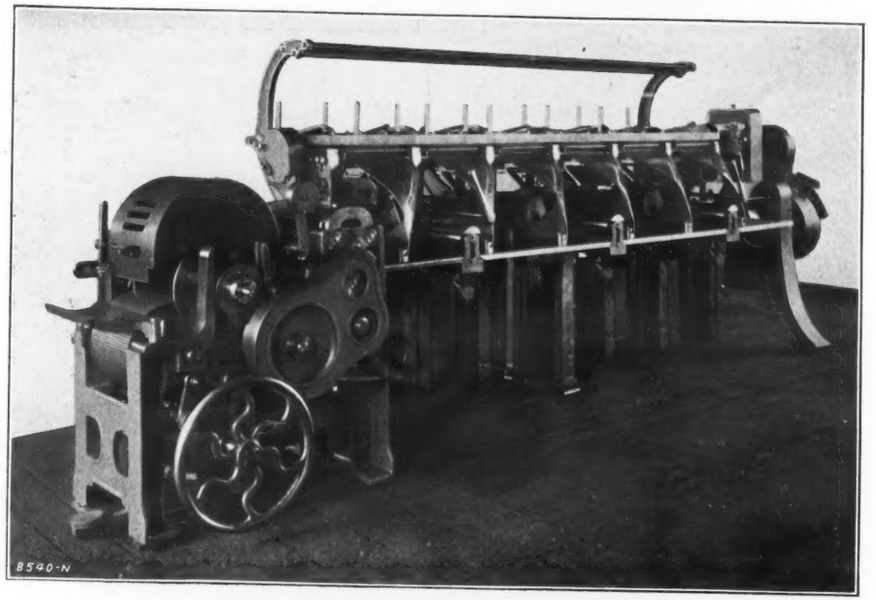

FIG. 22. RIBBON LAP MACHINE.

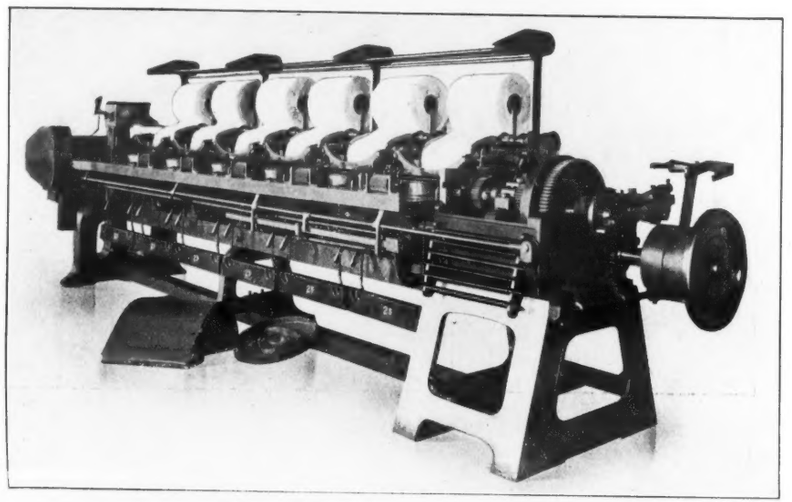

FIG. 23. NASMITH COMBER.

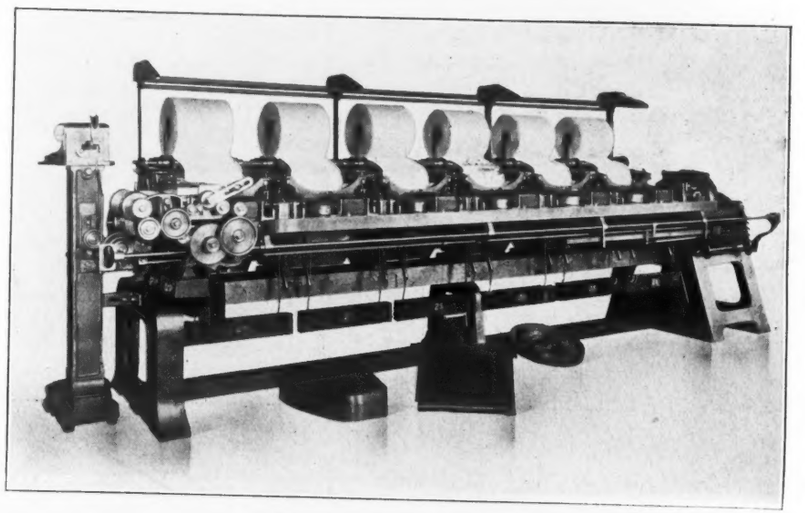

FIG. 24. NASMITH COMBER.

(*To face page* 91.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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ENGINEERING.

FRIDAY, JULY 18, 1924.

THE KELVIN CENTENARY CELEBRATIONS.

THE celebrations organised by the Royal Society, and by the Institutions of Civil, Mechanical, and Electrical Engineers, to commemorate the centenary of the birth of Lord Kelvin, have undoubtedly benefited by the large influx of visitors interested in scientific and technical matters, who have been attracted by the World Power Conference at the British Empire Exhibition. Kelvin's enduring fame, and the standing of the societies who have organised the matter, would have in any case assured a noteworthy assemblage, but in normal years so large a gathering as that which attended the presentation of the Kelvin medal to Professor Elihu Thomson could hardly have been expected. For reasons which are readily intelligible the distinguished delegates from foreign learned societies did not include representatives of "enemy" nations, but most other European countries sent their envoys to testify to the esteem in which the intellectual élite of all civilised countries hold the memory of one of the great creative minds of the Victorian era. The American representation was especially strong, but Lord Kelvin has long been honoured in the United States by the general public for the large part he played in establishing transatlantic telegraphy, and by physicists for his more purely scientific work. This appreciation led to the generous arrangements made for his famous Baltimore lectures.

Transatlantic interest in the proceedings were further stimulated by the fact that the Kelvin Medal was presented to Professor Elihu Thomson, whose bold and successful pioneering work in electrical engineering has well earned this recognition. The presentation was made on Thursday, the 10th instant, by Sir Charles Morgan, president of the Institution of Civil Engineers, in the Hall of that Institution. Sir Charles recalled the remarkable success attained in the early days of arc lighting by the Thomson-Houston machines, and the very remarkable work, both scientific and industrial, of Professor Thomson on alternating currents. To the new Kelvin medallist moreover, we owe one of the most successful methods of electric welding. We may add that the enormous development of electric power generation and distribution in America has been largely the work of the General Electric Company, of which Professor Thomson is the official head.

Professor Elihu Thomson said that he accepted the medal as also a tribute to his fellow-workers in America. He pointed out that amongst professional men the engineer alone was called upon to guarantee results. The lawyer, the physician and the clergyman gave no guarantees, but the engineer had to. This personal responsibility distinguished the profession of engineering from all others, and a recognition of it differentiated the school of technology from the ordinary college.

Addresses from the representatives of British dominions and foreign countries were then presented, the chair being occupied by Sir Richard Glazebrook, who said that the extraordinary scope of Kelvin's activities was well shown by the fact that he had been president of the Royal Society, the Institution of Electrical Engineers, the Mathematical Society, the Physical Society, the Faraday Society, and the Institute of Marine Engineers. There never had been so great a physicist who was so great an engineer. He made inventions as well as discoveries, and patents were as familiar to him as papers.

Sir J. J. Thomson, O.M., Master of Trinity, then delivered the Kelvin oration, which took the form of an historical sketch of Kelvin's life and work. This has recently been set forth in our columns,* and a repetition of the main incidents is therefore unnecessary, though Sir Joseph's inimitable style of presentation and witty turns of expression added characteristic charm to his discourse. One or two points may, however, be noted, viz., the curious fact that the two studies in which Kelvin took special interest to the very end of his life, viz., the figure of the earth and the Fourier analysis, were, as regards the first, started at the age of 12, and in the case of the other at the age of 17. His essay, written at the age of 12, on the figure of the earth remained one of his permanent sources of reference to the very end of the writer's life. The Fourier analysis was at that time considered so difficult that it was a question whether it was fair to demand a knowledge of it for the Mathematical Tripos; yet Thomson at the age of 17 completely mastered it in the course of a fortnight, and as a Freshman, not yet entered into residence at Cambridge, contributed an original paper on the subject to the leading British mathematical journal of the day. With such an intellectual endowment it is not remarkable that Lord Kelvin had, as Sir Joseph said, very optimistic ideas as to what might fairly be demanded from a boy of 12. He showed that Lord Kelvin had been able to write English, read French and one other language, translate Latin and Greek, and having thus learnt the meaning of words, took up the study of logic.

Lord Kelvin's sole learning in practical physics was obtained during the few weeks he spent in Regnault's laboratory at Paris. This was undertaken to increase his chances of success in a prospective candidature for the chair of Natural Philosophy at Glasgow. We may add that under the absurd views as to the primary importance of elementary laboratory work now held by the Board of Education, Thomson, so far from being eligible for the professorial chair, would not even have been admitted as a candidate for a scholarship. Routine laboratory exercises on dull and unimportant measurements are every bit as fatal to real education as the grinding which it has to some extent replaced.

The Master of Trinity noted the curious coincidence that Sadi Carnot's epoch-marking conception of the reversible heat engine appeared in the year of Kelvin's birth, and it was the development of this concept of Carnot that constituted perhaps the most important part of Lord Kelvin's life work.

* ENGINEERING June 20, 1924, page 799.

As a professor, Sir Joseph said, Kelvin was more successful as an inspirer than as an instructor. He filled some of his men with enthusiasm and others with despair. He was apt to wander away from the ostensible topic of a lecture into what might be specially interesting him at the moment.

Sir Joseph also referred to Lord Kelvin's reluctance to assimilate the ideas of others. It would seem to us, however, from the cases of Fourier and Carnot, that this characteristic can only have become pronounced after Kelvin had acquired confidence in his own methods of attacking physical problems. However it originated, this characteristic was certainly marked during his later years when he might be likened, Sir Joseph said, to what would be an unheard of anomaly, viz., to a body that "was a good radiator but a bad absorber." This was not altogether a disadvantage, as by approaching subjects from his own point of view instead of following the path traced by others, new light was often thrown upon the subject discussed. Kelvin's most striking characteristic, Sir Joseph said, was his tremendous knowledge of dynamics. He had the engineer's intuition as to how matter in motion would behave. He knew without mathematics what was likely to happen, and in this was to be found the secret of his success in the mathematical attack of physical problems.

The great problem which he had set himself almost in his 'teens of finding a mechanism for the luminiferous ether was pursued for 50 years, with what Lord Kelvin himself termed failure, but like the agriculturalist who dug his orchard in search of a fabulous hoard of gold and incidentally secured a prodigious crop of fruit, Lord Kelvin found many other things of first importance in the course of his research. At the date at which he started on his career the difficulties appeared less than they would to-day. The undulatory theory of light was then accepted as a complete geometrical interpretation of optics. According to this theory, light corresponded to transverse waves in an elastic solid, and the problem was to find the nature of a medium which would suppress longitudinal waves, transmit transverse waves and allow bodies to pass through it. The Baltimore lectures were specially devoted to this. It was now recognised, however, that the undulatory theory could not account for the electrical properties of light, for which something more akin to Newton's corpuscular theory was required, whilst on the other hand the corpuscular theory failed to explain optics. It would seem, Sir Joseph said, that each theory contained only a part of the truth as to the structure of light. The energy of light appeared to be concentrated in neuclei which generated waves. These waves accompanied the neuclei, but of themselves possessed little energy, although they determined the path of the neucleus through space. When Maxwell introduced his electro-magnetic theory, Kelvin thought that the cart was being put before the horse. He assumed that the business of light was to explain electricity and not of electricity to explain light. He was, in fact, trying to get at something more fundamental than Maxwell's theory.

The treatise of Thomson and Tait on "Natural Philosophy" brought about, the speaker proceeded, great changes in the teaching of Mathematics at Cambridge. The text books previously in use, ceased to discuss a problem once the equations had been found and the work, therefore, left off just where it should have begun. Thomson and Tait said the equations were not abandoned until the whole of the mechanical and physical implications had been extricated.

The successful laying and operation of the Atlantic Cable in 1866 was largely due to Kelvin's ability and courage. It was a marvellous achievement for one whose prior experience was in the laboratory to have met all the difficulties that arose in passing from the instrumental to the engineering scale, and which made such an operation much more harassing than purely experimental work could ever be. The engineer had, moreover, to work with and through others, and this meant that he had to keep in working order that most capricious of all scientific instruments, namely, man himself.

Sir Joseph recalled that Kelvin was a keen yachtsman, and this led to his taking such an interest in navigation that a naval authority credited him with having done more for the subject than any man of his time.

THE BRITISH ASSOCIATION.

NEXT Saturday, July 26, the main British party will sail by the Caronia from Liverpool to Quebec for the British Association meeting at Toronto, the fourth visit of the Association to Canada, and the second to Toronto. When the Montreal meeting of 1884 was proposed, the objection was raised that, though the activities of the British Association were not limited to the United Kingdom and Ireland, its meetings should be held within the country. After Montreal nobody questioned the wider interpretation of British in this connection, and the Association went to Toronto in 1897, to South Africa in 1905, to Winnipeg in 1909, and to Australia in 1914.

This year the invitation comes from the University and the Royal Canadian Institute (founded 1849) of Toronto, and is endorsed, as before, by the whole Dominion. The population of Canada, a country nearly as big as Europe, had risen from 2,400,000 in 1851 to 8,788,483 in 1921. Both Montreal and Toronto are at present cities of half a million inhabitants. The colleges of Toronto, the first of which dates from 1827, are now a University with 5,000 students and with splendid spacious buildings, laboratories and social halls, which will afford ample and convenient accommodation for the large meeting that is expected. Everybody who has signified his intention of attending, and who does not prefer to make his own arrangements, has weeks ago been assigned his quarters in Toronto. The efforts of the local committee deserve warmest thanks also for this reason. Their task is exceedingly arduous. Nearly six hundred members will come over from the Old Country and will be joined by a large number of foreign guests. That Canadian scientists will attend by the thousands is certain, and American science would not fail to participate even if Toronto were not so near the frontier. Finally an International Mathematical Congress, the seventh of its kind, is to be held in Toronto on the days August 11 to August 16, the last days overlapping with the Association week, August 6 to August 13.

On Wednesday, August 6, Sir Ernest Rutherford, this year's President of the Association, will vacate the chair, and the president elect, Major-General Sir David Bruce will deliver his address on "Prevention of Disease." He will no doubt dwell on the remarkable work of Drs. F. G. Banting and of J. R. MacLeod and their Toronto colleagues on insulin. Several papers on these problems and on chemotherapy (presidential address of Dr. H. H. Dale) will come up in Section 1, Physiology. The programme of Section G, Engineering, will be found on page 94 of this issue; Mr. Gaby's paper on "The Hydro-electric Power Commission of Canada" and Mr. R. S. Lea's paper on the "Development of the St. Lawrence for Power and Navigation" may be singled out as the most noteworthy contributions.

Section A, Mathematics and Physics, will be more than busy. Sir William Bragg's presidential address on "X-ray Analysis of Crystal structure" is to introduce a joint discussion with Section B. Sir Ernest Rutherford will lecture on "Atomic Disintegration," and Professors A. H. Compton and W. Duane will bring the questions of radiation and the quantum theory up. The other chief subjects are spectra and conigation, covering papers by Professor A. Fowler, by Messrs. Foote and Mohler, R. H. Fowler, I. Langmuir Raman, L. F. Richardson, and F. J. W. Whipple, on the green flash, the scattering of light and acoustical research, by Professor P. E. Sabine and Sir Richard Paget, and papers on radiation from stars by Professor Eddington, on radiation pressure by Mr. E. A. Milne, on space-time by Dr. Silberstein, on the spectra of nebulæ by Dr. H. H. Plaskett and on tidal function by Dr. H. Jeffereys. There are further meteorological papers by Sir Napier Shaw and others on wind, atmospheric turbulence, rains and on seismology. Professor J. C. McLennan will enable members to visit the Cryogenic Laboratory, in which the liquifaction of helium and other low-temperature research are being carried out.

In Section B, Chemistry, Sir Herbert Robertson will deliver a presidential address on "Chemistry and the State," and discussions on "Vitamins," which so far have had little chemistry consideration, on "Liquid and Powdered Fuels," and on "Colloid Solutions," will occupy much of the time. Of other subjects we may mention are "Activation of Nitrogen" by Professor W. A. Bone, and the "Separation of the Elements of the Rare Earth" by Messrs. J. Kendall and B. L. Clarke. Many of the papers to be discussed in Sections C. Geology (president Professor W. W. Watts), Geography (president Professor J. W. Gregory), K. Botany, H. Anthropology, M. Agriculture (president Sir John Russell) will have particular bearing on Canada.

Several of the sections will also have to meet on Saturday, which is the excursion day for Niagara. The great trans-continental excursion, in which 190 members will take part, is to leave Toronto on August 17 and return to Quebec in time for visitors to sail, by September 4. The party will make special stays at Edmonton and Saskatoon. There will be other excursions, in addition to the local receptions, discourses, &c., and there is every prospect that the organisers of the Toronto meeting, Professor J. C. McLennan, Professor J. C. Fields, who is organising the Mathematical Congress, Professor W. A. Parks, who has edited the excellent handbook of Canada, and their many colleagues, will be able to congratulate themselves upon enjoyable, successful and memorable, though arduous, meetings.

THE WORLD'S MERCHANT SHIPPING.

IT is a matter of some interest and importance to take stock, from time to time, of the character and extent of the world's merchant fleets, in order to note the changes that are taking place in their composition as well as in the relative positions of the maritime nations. A convenient opportunity for reviewing the position is provided by the issue, about this time each year, of Lloyds' Register Book, which contains, in addition to particulars of each individual vessel, a wealth of statistical data on shipping matters. A complete analysis of these data and a comparison with those for previous years, would enable the present position to be appraised with reasonable accuracy, and would also provide the best possible information upon which to base a forecast of the future trend of the shipping industry. The task, however, would be one of considerable magnitude, and the space at our disposal is only sufficient for the presentation of such features as are evident from a more cursory examination of the figures.

One noticeable feature of the statistical tables accompanying the current issue of the Register Book, is that there has been an actual decrease of upwards of 1,000,000 tons in the total merchant shipping owned in all parts of the world since the previous edition was issued a year ago. This is doubtless due to the circumstance that the prevailing low freights have caused shipowners to dispose of large quantities of inefficient tonnage for breaking up, and the continued general depression of the shipping industry has delayed the construction of tonnage for replacement purposes. A year ago, the world's total of merchant shipping was 65,166,238 tons, while the corresponding figure for June of this year is 64,023,567 tons. The total for steamers and motor ships alone has declined during the year from 62,335,373 tons to 61,514,140 tons, the difference of 821,233 tons being a reduction of 1·32 per cent.

For Great Britain and Ireland, the total tonnage is now 19,105,838, of which 18,954,158 tons are steamers and motor ships, while the figures for June of last year were :—Total tonnage, 19,281,549, and steamers and motor ships, 19,115,178 tons. The reduction in the latter class of vessels thus amounts to 161,020 tons. Most other countries show similar reductions in the total tonnage owned, although Germany and Japan are notable exceptions to this rule. German merchant tonnage has increased by 363,598 tons (14 per cent.) during the

year, the figures being 2,590,073 tons a year ago, and 2,953,671 tons at the present time. For Japan, the current figure is 3,842,707 tons, while that for June, 1923, was 3,604,147 tons, the increase of 238,560 tons, in this case, amounting to 6·6 per cent. A considerable reduction in the sea-going tonnage of the United States has also to be recorded, the current figure of 13,530,544 tons being 1,066,491 tons (7·3 per cent.) lower than that for a year ago, while for France and Italy the reductions amount to 239,011 tons and 201,530 tons, respectively. It should be stated, however, that about one-third of the reduction in tonnage mentioned in the case of the United States is accounted for by the withdrawal from the new Register Book of Government vessels not used for mercantile purposes.

There are still, it appears, about 1,500,000 tons of wood and composite steamers in existence, but, in view of the low economic value of these vessels, a more accurate comparison of the relative positions of the world's merchant fleets can be made by considering steamers and motor ships of steel and iron construction only. Of this class of shipping, the world's total tonnage is now 57,530,000, as compared with 42,514,010 tons in June, 1914, the difference of 15,016,000 tons representing an increase of 35 per cent. for the decade. While the world's tonnage has increased as stated, the tonnage now owned in Great Britain and Ireland is practically the same as the figure for 1914. The British and Irish merchant tonnage of the class of shipping to which we are referring now amounts to 18,917,000, and forms rather less than one-third of the world's total in the same class, whereas in 1914 it amounted to over 44 per cent. We still, of course, own the world's largest merchant fleet, but are more closely followed by our rivals than was the case prior to the war. At that time, the second place was held by Germany with 5,098,000 tons of iron and steel shipping, whereas the United States, which now comes second, has a sea-going merchant fleet of 11,823,000 tons and accounts for just over 20 per cent. of the world's total.

The other leading countries in order of magnitude of iron and steel tonnage owned are:—Japan (3,655,000 tons); France (3,193,000 tons); Germany (2,856,000 tons); Italy (2,676,000 tons); Holland (2,533,000 tons); and Norway (2,326,000 tons). With the exception of Germany, all these countries have made material additions to their merchant fleets during the past decade, the largest increase having occurred in the case of Japan, which has added over 2,000,000 tons. The current German tonnage is now only 56 per cent. of the corresponding figure for 1914, although some indication of the extent of that country's efforts to regain her pre-war position among the maritime nations is given by the fact that she has increased her iron and steel merchant shipping by 360,000 tons during the past year. It will thus be evident that the present German mercantile marine contains a large proportion of new tonnage, and since the latter must be regarded as of relatively high efficiency, this fact should be considered in comparing the positions of different countries. Actually, of the present German tonnage, about 52 per cent. is less than five years old, and this proportion of new tonnage is greater than that of any other nation. In the case of Great Britain and Ireland, the proportion of new tonnage is only 26·1 per cent., a figure which is exceeded by those for Holland, Denmark, France, the United States and Norway. For Holland, Denmark and France, the proportions of new tonnage are 36·8 per cent., 33·7 per cent., and 32·28 per cent., respectively, while those for the United States and Norway are both just over 30 per cent.

The development of the motor ship, to which we referred on page 52 *ante* when discussing current shipbuilding work, is still further illustrated by the data relating to existing vessels of this class which are now available. The new Register Book includes a total of 1,950 motor ships and sailing vessels fitted with auxiliary motors, and these vessels, having an aggregate tonnage of 1,975,798, account for 3·09 per cent. of the whole tonnage of the world. A year ago, the proportion was 2·56 per cent., and in 1914 it was as low as 0·45 per cent., the tonnage of motor ships at that time amounting to only 220,000. The relative importance of other types of machinery can be gauged from the fact that nearly 80 per cent. of the total existing tonnage is propelled by reciprocating steam engines, and nearly 14 per cent. by steam turbines. In about 29 per cent. of the existing steam tonnage the boilers are fired by oil fuel, and this oil-fired tonnage now constitutes 26·79 per cent. of the whole world's merchant shipping as compared with 2·65 per cent. which was the corresponding figure for 1914. Oil is thus at present used for the propulsion of about 30 per cent. of the world's shipping, and as the proportion of sailing tonnage is approximately 4 per cent., it will be seen that coal is only required for slightly less than two-thirds of the total tonnage. Ten years ago, when sailing ships accounted for about 8 per cent. of the total tonnage, the proportion of vessels employing coal for fuel was just under 89 per cent., while oil fuel was only used on the remaining 3 per cent.

Many other interesting and important facts could be obtained, either directly or by analysis, from the valuable tables in the Register Book, and to one of these, which may be taken as an indication of the general effect of the war upon the development of merchant shipping, we propose to refer in conclusion. From a table showing the total tonnage owned by all countries of the world for the past 35 years, it appears that during the three consecutive decennial periods commencing in 1894 and terminating at the present time, the world's tonnage has increased by 10,052,000 tons, 14,106,000 tons and 14,639,000 tons respectively. The increase amounts to practically 40 per cent. for the first two decades, but was slightly less than 30 per cent. for the last decade. Had it not been for the advent of the war, which was, of course, included in the last period, it seems probable that the percentage increase in tonnage between 1914 and 1924 would have been, at all events approximately, equal to that of the two previous decennial periods, and that some 69,000,000 tons of shipping would now be normally engaged in carrying the world's commerce. Actually, as is well known, the 64,000,000 tons now in existence is in excess of present requirements and a considerable proportion of it is consequently idle.

Finally, we should mention that the tonnages quoted above are gross in all cases and the statistics, as usual, include all vessels of 100 gross tons and upwards.

METALLURGY AT THE BRITISH EMPIRE EXHIBITION—V.

ONE of the most prominent displays in the Palace of Engineering is that made by Messrs. Vickers Limited, and their associated companies. Their ferrous metallurgical exhibits, particularly as concerns their Sheffield works, in order to be fully representative, should have included whole series of armour plates, heavy gun component parts and projectiles of every calibre, in the manufacture of which the firm have specialised for many years past. Most of these, however, are of such great size and weight that it was found impossible to arrange on the stand a comprehensive selection. For this reason, also in consequence of transport difficulties and insufficient lifting gear at Wembley, Messrs. Vickers' exhibits of ferrous-metallurgical products have in the main been limited to other specialities of theirs, chiefly to those manufactured by them for general engineering purposes.

These are in great variety, and taking first for our brief review the products of their steel-pressings department we may mention several chassis side frames of high tensile, nickel steel, including one 25 ft. 6 in. and one 27 ft. 9 in. in length, a completely riveted-up chassis frame for a motor car, a variety of cross members for motor-car frames, a patented gear-case for a tramway car, concrete slab moulds, &c. This department, originally intended for the manufacture of underframes for all types of vehicles, has since extended its activities to various classes of pressings and sheet-metal work. The plant is capable of dealing with motor-vehicle underframes up to 28 ft. in length, in $\frac{1}{16}$-in. thick high tensile steel, and some of the largest commercial vehicle underframes used in this country have been manufactured by Messrs. Vickers. In addition to chassis component parts, pressings are made in either mild, 3 per cent. nickel, high carbon, bullet proof or rustless steel, or in aluminium or duralumin. The firm have also specialised in the manufacture of discs and rings of special alloy steels for the textile and other industries. Near the display of pressed work is a small selection of their "Vikro" castings. This is a special alloy remarkable for its great resistance to scaling and oxidation at high temperatures, and for the much greater strength it possesses over ordinary steel in the red hot state. The first cost is comparatively high, but this is fully justified when considering the greatly increased life in good working condition of the part when made of "Vikro."

Laminated springs for motor cars, motor lorries and railway vehicles, and helical and volute springs are also a feature of Messrs. Vickers' stand. The manufacture of springs was started by them immediately after the war, and the demand for their springs soon developed to such an extent that they had greatly to extend the original plant they put down for their manufacture. In this connection, Messrs. Vickers state that their success in this branch is due in a large measure to the active co-operation of the staff of their Research Department with the men in charge of the actual manufacture in their spring-making department. At the front of the stand can be seen a log band saw 39 ft. 6 in. long and 6 in. wide. Band saws are made by them in large numbers for cutting both metal and wood. An adjoining exhibit is a case containing fractured test specimens of ordinary carbon and special steels for all purposes, including aeroplane and motor car construction. In front of this is a case containing samples of files and hack saws, made at Messrs. Vickers' Holme Lane Works. During the war these works were entirely devoted to the production of field-artillery shrapnel shell; after the war the machines for this were disposed of and the works re-equipped completely for the new specialities. At the back of the stand are several bullet-proof steel plates which have been fired at with both British and foreign ammunition at close range; as can be seen none of the rounds have penetrated the plates. Plates of this quality steel were made in large numbers during the war for protecting the side of tanks, armoured cars and for other war purposes. The mill in which they were produced now serves for the rolling of commercial sheets.

An illustration of the very high quality of the steel made many years ago by Messrs. Vickers is afforded by their locomotive crank axles, one of which, situated on the stand, has been in constant service for 35 years on a locomotive of the New South Wales Railways, in which it had travelled 759,909 miles before it was necessary to discard it, owing to a small surface crack which had developed in service. Straight railway axles are also shown, one of which has been bent double under test without showing any surface defects.

The construction of guns, as is well known, necessitates, among other equipment, a most accurate machining plant, operating cutting tools which can be completely relied upon from beginning to end of a job—such, for example, as boring and rifling tools for gun tubes. A case on Messrs. Vickers' stand contains specimens of their steel-cutting tools, including the famous "S.R" cutter, which revolutionised the speed of boring the whole length of long gun tubes and hollow shafts for marine engines. The speed and accuracy with which these cutters penetrate steel is remarkable; from the point of view of speed alone they have in many instances curtailed the time taken for boring to a third that which formerly obtained when using ordinary drills. Cast cutters are also shown.

During the war Messrs. Vickers put down at the special request of the Government a tube-making plant, since the authorities were experiencing much delay and difficulty in obtaining alloy steel tubes of the high quality and exceptional strength required for aeroplane building. So successful did these tubes prove in actual practice that Messrs. Vickers were requested to double their plant in order to meet the ever-increasing demands made by the Air Force towards the close of the war. This department, like many others which were specially set up for

war purposes, suffered a great reduction of orders after the armistice, when it became necessary to build up a business in tubes for other purposes. In this speciality also they have been successful, the high quality of their cold-drawn seamless steel tubes having acquired a world-wide reputation. Sections of tubes made by the firm form part of the display.

One of the commercial steel products for which the firm have been known for as many as 60 years past, both at home, in the British colonies and dominions, and in foreign countries, are their steel railway tyres. Many foreign railways have generally required such tyres in their specifications and a number of foreign steel works have offered to supply, to the railway, tyres of their own manufacture, of "bandages de qualité Vickers." This testifies to the reputation the firm have acquired as makers of the highest grade of railway tyres obtainable. Their "Australia" brand of tyres has been, and is still, recognised as the very best by the leading locomotive engineers on all the principal railways, who usually specify that their locomotives, more especially those required to deal with particularly heavy traffic, shall be fitted with tyres of Messrs. Vickers' manufacture. Messrs. Vickers make these of any required diameter. The largest ring on the stand, having a diameter of 9 ft. 9 in., is not a railway tyre proper; its object is simply to illustrate the capacity of Messrs. Vickers' tyre mills and to show that they are able to produce such rings when required for any special purposes. Near this large ring is a tyre forming the frame of a show-case in which are displayed various tyre sections rolled or different railways.

The Drop Stampings Department is another important section of the firm's Sheffield works. Messrs. Vickers were among the pioneers in the manufacture of forgings by drop stamping, and this department is the largest in the country for the class of work in which it specialises. The firm shows a number of drop forged crankshafts for internal combustion engines of all types, also axles for motor cars and commercial vehicles. In addition to these exhibits, there are two oil-well boring tools manufactured as drop forgings. A group of stainless iron, highly polished golf club heads, which are sure to find favour with many visitors, is also displayed. A very large roller bearing—the largest ever made—to an order for Messrs. The Chain Roller Bearing Co., Stockport, for paper machinery in Canada, can also be seen on the stand. Another exhibit, and one that will appeal to railway engineers, is the new design of axle-box for 10 and 12-ton wagons.

Mining engineers, for their part, will be interested in the Vickers patent unbreakable winding drum, which is manufactured at the Barrow works. Two exhibits by these same works are those which we illustrate herewith: one is a main gear wheel for double-reduction gearing, and the other is two water-turbine rotors. The gear-wheel centre is of cast-iron in one piece. A heavy weldless, forged-steel rim is shrunk on the centre and secured to it by screwed steel pins. The steel of which the rim is made has a tensile strength of 34 tons per square inch. The teeth are of the double-helical, involute type of 1-in. normal pitch and 30 deg. helical angle; they have been cut by the hobbing process on a special gear-hobbing machine. The wheel is capable of transmitting at total of 4,500 shaft horse-power when running at a speed of 90 r.p.m. The pitch-circle diameter of the wheel is 8 ft. 7½ in., the total width of gear face being 39 in. The wheel weighs 16 tons. The water-turbine rotors are of the reaction type. Their steel plates are held in cast-iron hubs and rims. They are to be installed in India to drive irrigation pumps. Operating as they will under a low head of 6 ft., the construction is light, although high efficiency and long life are guaranteed. We may here remark that Messrs. Vickers own a complete installation for the design and manufacture of water-turbine plant, an industry which had generally been comparatively neglected in this country up to the end of the war. They are successfully developing this branch of their business. The gear wheel and the water-turbine rotors are illustrated in the views, Figs. 2 and 3 herewith.

Messrs. David Colville and Sons, Limited, Glasgow, together with their associated companies, have a varied exhibit ranging from coal specimens to finished iron and steel products in great variety. Their rail sections include the lightest for mines, quarries and contractors' work to the heaviest, both flange and bull-head rails for main railways, and bridge rails for special purposes. They also manufacture steel sleepers for normal gauge and other gauges, and show samples of these complete with rails, clips and fishplates. A panel carries a large circular arch for mining work, inside which are placed other ∩-shaped arches, the smallest, in the centre, representing a section of a mine gallery, with tub and rails in position. Glass cases contain a very large number of shipbuilding and structural

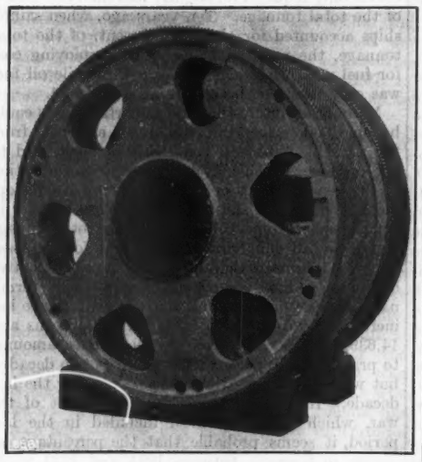


FIG. 2. MAIN GEAR WHEEL FOR DOUBLE REDUCTION GEARING.

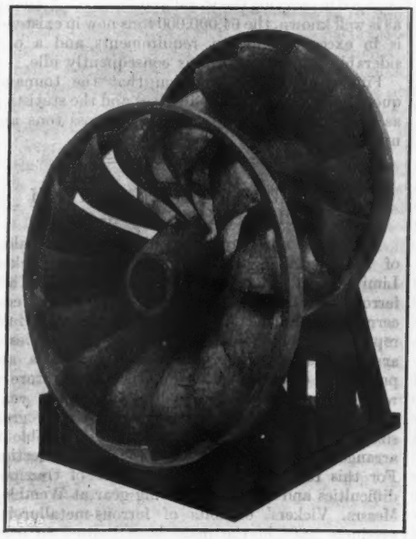


FIG. 3. WATER TURBINE ROTORS.

steel sections, test bends, flange rail joints with angle and with ordinary fishplates. The firm's "Ducol" steel deserves special mention. It has the combined properties of high tensile and mild steels, having both strength and ductility. This steel has a breaking strength of 39 tons per sq. in., and elastic limit of 19·5 tons, with an elongation of 21 per cent. in 8 in. Three bent samples of this are shown, one being a flat bar 4 in. wide and weighing 30 lb. per ft., the original length of which was 14 ft., but doubled to and fro upon itself over the whole length, in the cold, the test showing the reliability of the metal at any part of the bar. The two other specimens are doubled up bars 3 in. and 5 in. wide. Messrs. Colville use this steel for all purposes where saving in weight together with retention of strength under adverse circumstances have to be met jointly, the steel finding current application in structural work, shipbuilding, marine-boiler work, where lightness, strength and reliability are primary conditions. The steel will stand any heat treatment to which other boiler steels are submitted. Cold twisted specimens of this same steel can also be seen on the stand. A joist made of "Ducol" steel is shown. This has undergone a severe drop test; a 1 ton weight has been dropped upon it four times from a height of 20 ft., in each case on the cold joist, on which can be seen the dents made by the weight, but no fracture of any kind, the joist remaining sound throughout. It would still have held in any structure of which it formed part. An ordinary steel joist would in all probability have suffered far greater damage under similar test conditions. The joist has a tensile strength of 39·2 tons per sq. in., an elastic limit of 20·2 tons and an elongation of 18 per cent. in 8 in. "Ducol" steel is a straight carbon steel, its properties being the result of special treatment during the process of manufacture. Other samples of Messrs. Colville's products are their "free-cutting" steel, or steel which can readily be machined; corrugated bars for reinforced concrete work; "bamboo" and "Milan" steels; horseshoe bars; pressings made of the firm's steel sheets, including intricate specimens and a deep one of small diameter. A decorative panel consists of a steel sheet 9 ft. × 5 ft.; steel sheets are rolled up to 20 ft. on length, 6 ft. 4 in. in width, in thicknesses varying from $\frac{1}{8}$ in. down to 28 G. One remarkable specimen is a mill-finished boiler-end plate 13 ft. 8 in. in diameter and $\frac{15}{16}$ in. thick, close to this are tube billets for solid drawn tubes, also several drawn tubes. The quality of the Colville steel is evidenced by a collapsed boiler furnace, a test in actual practice which will appeal to all boilermakers. A glass case contains the firm's special alloy and tool steels, on which is placed a rivet snap which has closed as many as 31,754 rivets; this has not been touched up and is still in good condition. The stand also contains Clyde Alloy shear blades of large and small sizes, and of different shapes, a cast-steel gear wheel about 5 ft. 10 in. in diameter, and a length of a stud cable chain, the links being steel castings. The centre of the stand is occupied by a pyramid of heavy steel rolled blooms for forging work, the largest of which measures 36 in. square and 4 ft. 6 in. long. The exhibit also includes the model of a pit-head frame complete. The concern own the only anthracite mine in Scotland, and show a block of anthracite, anthracite nuts and other qualities of their coal, together with specimens of their patent fuel. The companies associated with Messrs. David Colville are the Clyde Alloy Steel Co., Limited, Messrs. Smith and McLean, Limited, the Murdostoun Colliery Company, Limited, Messrs. Russell, Archibald, Limited, the Polmaise Patent Fuel Company, Limited, and the Carnlough Lime Company, Limited.

The Earl of Dudley's Round Oak Works, Limited, Brierley Hill Staffordshire, have a display of iron mooring chains and links, including a square link weighing 5¼ cwt. The chains and links have been tested to 400 tons. A 77 cwt. stockless anchor, sections of structural steel, test specimens, and iron castings for motor-car cylinders are also shown.

THE NATIONAL PHYSICAL LABORATORY.

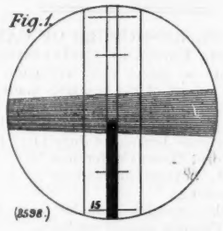
(*Concluded from page* 6.)

Direct Current and Cables.—Cable research is being continued on behalf of the British Electrical Research Association, with special regard to the influence of high temperatures (studied in stoves) and of water (studied in a trough of 80 ft. length), and also on the resistance of porcelain at high temperatures. Determinations of the current-rating of cables and of bus-bars (copper and aluminium) go together with this work. The department is also testing the corrodibility of resistance heater coils and their bases under severe conditions, in stoves in which they are exposed to sprays of salt, acid, &c.; similar duration tests are applied to rustless steels. The use of a large-size thermionic valve as a resistance on high-tension circuits is novel; the point is that the resistance can be changed continuously,

and not only in steps, simply by changing the filament current.

Photometry Division.—The Heterochromatic Photometry Sub-Committee, appointed at Paris in 1921, on which Dr. Rayner and Mr. J. W. T. Walsh represent the Laboratory, will report to the International Commission which is to meet in Geneva at the end of this month. The object is to develop a furnace capable of serving as a primary standard of radiation up to the highest temperatures. If the experimenter can keep a black-body furnace at any definite temperature, and get a colour match of the furnace against a tungsten lamp, then he can use the lamp as a high-temperature pyrometer. The lamp current is varied until the colours of the furnace and the filament are identical, and luminous efficiency (watts per candle) can thus be correlated to colour temperature. More has been done in America in this field than over here. The work on motor-car headlights is creeping on, without bringing any decision tangibly nearer. As regards ships' lights, the Laboratory supplies standards of coloured glasses to the Board of Trade. Simple transmission tests, based upon the glass thickness, are not possible with red glasses, because they are "flashed," but members of the Laboratory are enabled to make their selection of suitable portions of the glass at Messrs. Chance Brothers' works; green glasses, which are through-coloured, allow of adjustment to other thicknesses. The general work on illumination and on the daylight factor has been noticed in our columns on other occasions.

Metrology Department.—The Metrology Department is the only one which has reduced its staff, the reduction being from 77 to 71, due to the



falling off in routine glass and hydrometer testing. There was also a reduction in the numbers of end gauges tested, though there was more demand for the testing of cylindrical and screw gauges. The discrepancy between the Laboratory and the Bureau International des Poids et Mesures at Sèvres as to the length of the metre bar has been partly cleared up; but there remains a slight difference, and it looks as if the old metre bar N = 16 (of nickel) of the Laboratory, which had been accepted as principal reference standard, had undergone some change. One possible source of error is the "asymmetry" of most observers, to meet which observations are taken at the Laboratory with the observer standing first in front, and then behind the comparator. But the opinion seems to gain more and more favour that mass standards are not really reliable, and that the wave-length will have to be adopted as the ultimate standard of length. In other respects, the work of the department on line and end measures, tapes and wires, has not given any trouble. The constants of the formula for the compression of steel balls which we gave last year, has been slightly corrected into: compression $= 0{\cdot}000028\, p^{\frac{2}{3}} \left(\frac{1}{d}\right)^{\frac{1}{3}}$ in., where compression is the mutual approach of the flat measuring faces after they have just made contact with the ball on each side, p the pressure in lb., and d the diameter in inches.

The interferometer method of measuring the length of gauges which we described two years ago, is in regular use. The calibration of the 3-in. by 12-in. pitch measuring machine, also described in that year, has been completed. Developments of other measuring machines have been noticed in connection with the British Empire Exhibition. The gear-measuring machine, which we illustrated last year, is doing all it promised and has also been utilised for the measurement of a set of Johansson angle slip gauges, previously carried out by means of the spectrometer; the probable error of the machine did not amount to more than 2 seconds of arc. With the aid of the modified Blythwood ruling engine (noticed last year) and a new double pawl, gratings are now ruled with 28,800 lines to the inch.

The graticule of Mr. Stott for reading telescopes, which we illustrate in Fig. 1, enables a fractional reading to be taken directly without the aid of a micrometer eyepiece. The wedge of 20 convergent lines, 25 mm. in length, has a width of 4 mm. at the right-hand end and of 2 mm. on the left. The graticule is mounted in the focal plane of the objective in which it can be traversed horizontally and vertically. When the adjustment has been made so that the graticule appears in the field of view between two scale divisions as in our diagram, a reading can be taken at a glance.

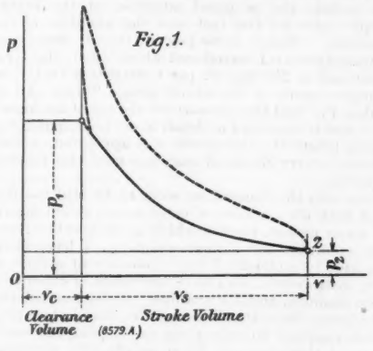
We finally mention a report on the expansion of concrete, presented to the Engineering Research Board, but not yet published. It will be of great interest to engineers. Concretes have been studied for two years, indoors and out-of-doors, at ordinary temperatures and at 34 deg. C. The thermal coefficients are of the order of that of steel, but there is a tendency to contraction in-doors and seasonal variations are observed out-of-doors. The final results of age, generally an increase in length, are most marked on fully-exposed blocks.

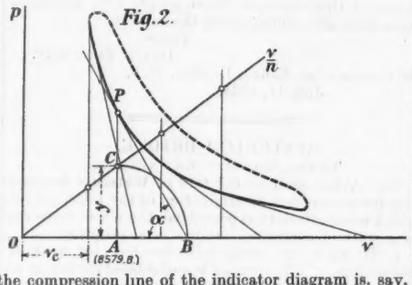
LETTERS TO THE EDITOR.

METHOD OF DETERMINING THE CLEARANCE OF INTERNAL COMBUSTION AND STEAM ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The usual method for approximating the clearance of an internal combustion engine cylinder is based on the assumption that the average exponent for





the compression line of the indicator diagram is, say, $n = 1{\cdot}3$. Then, according to Fig. 1

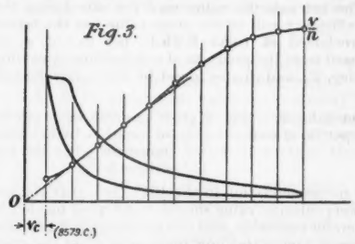
$$p_1 v_c^{1\cdot3} = p_2 (v_s + v_c)^{1\cdot3}$$

$$\frac{p_1}{p_2} = \left(\frac{v_s}{v_c} + 1\right)^{1\cdot3}$$

hence

$$v_c = \frac{v_s}{\left(\frac{p_1}{p_2}\right)^{\frac{1}{1\cdot3}} - 1} \quad . \quad . \quad . \quad (1)$$

In commercial tests of internal combustion engines, the clearance volume is usually calculated by this method (see W. A. Tookey, Commercial Tests of Internal Combustion Engines, Proceedings of the Institution of Mechanical Engineers, January, 1914, page 15). Clayton (A New Analysis of the Cylinder Performance of Reciprocating Engines, Bulletin No. 58, University of Illinois Engineering Experiment Station, 1912), bases his approximation on the assumption that n is a *constant* during the compression period, rather than assigning a specific average value to it. He assumes different values of clearance and plots the logarithmic diagram for each assumed value. The one which gives a straight line in the logarithmic chart is supposed to represent the true clearance. The analytical method of W. Inchley (The Theory of Heat Engines, 1913, page 294) and that of A. H. Stuart (ENGINEERING, June 11, 1920, page 782) are based on the same assumption, only "cut and try" is eliminated.



In cases where n is a constant through or over a portion of the compression line, the clearance volume can be ascertained with less effort in the following way:

Plot the $\frac{v}{n}$ line, as shown in Fig. 2, by drawing tangents (preferably with a mirror rule*) to the compression line and determining the projections thereof. If n is constant, the line obtained will be a straight line. In this case the continuation of the straight line intersects the zero pressure line just at the zero volume point, indicating the correct clearance.

In certain cases the $\frac{v}{n}$ line will not result in a straight line, indicating that n is not constant. If a section of the $\frac{v}{n}$ line is straight (as in Fig. 3) the continuation of this straight portion will determine the true clearance. If the $\frac{v}{n}$ line has no straight portion, it is advisable to use equation (1) for the approximation of clearance. The constructions shown in Figs. 2 and 3 can also be applied to determine clearance of steam engines, only it is preferable to base it on the expansion line instead of the compression line, because the compression line here is usually too short.

Proof of the construction in Fig. 2 is as follows:—

$$p\, v^n = \text{const.}$$

$$\tan \alpha = \frac{d}{d\, v} p = \text{const.}\ (-n)\, v^{-n-1} = -n \frac{p}{v}$$

In Fig. 2

$$\tan \alpha = \frac{\text{A P}}{\text{A B}} = \frac{p}{\text{A B}}$$

consequently

$$\frac{p}{\text{A B}} = -n \frac{p}{v}$$

hence

$$\text{A B} = -\frac{v}{n},$$

and also

$$y = \text{A C} = \frac{v}{n}.$$

When $y = o$, $v = o$, corresponding to the point of zero volume.

Yours truly,

P. H. SCHWEITZER,

Assistant Professor of Engineering Research.

The Pennsylvania State College, Pa.

June 6, 1924.

THE STANDARDISATION OF BOILER TESTING.

TO THE EDITOR OF ENGINEERING.

SIR,—It was with interest that I read the leading article dealing with "The Standardisation of Boiler Testing" in the issue of ENGINEERING, published on July 11, and if I may be allowed to encroach on your valuable space, I should like to add a few remarks on the subject.

The work of the Committee at present undertaking the revision of the Heat Engine and Boiler Trials Code, which was recommended by the Institution of Civil Engineers in 1913 is being anxiously watched by all engineers interested in steam generation. Indeed, the matter is one of first importance to boiler manufacturers, engine manufacturers and power station engineers alike, and in view of the urgent necessity of a practicable standard code, it is hoped that the publication of the recommendations of the present Committee will not be unduly delayed.

* See *Power*, April 10, 1924, p. 554.

In the past, one of the most contentious points in calculating the efficiency of a boiler has been the correct determination of the calorific value of the fuel. According to the 1913 Code, the calorific value may be given as follows :—

1. The gross calorific value of the sample of fuel as fired should be determined in a compressed oxygen bomb-calorimeter, all the products of combustion being taken as cooled down to 60 deg. F.

2. The net calorific value used for calculating the boiler efficiency will be the gross value less the latent heat (reckoned at 1,055 B.Th.U. per lb.) of water condensed from the products of combustion by cooling to 60 deg. F., and can be found by the following formula :—

$$\text{Net calorific value per lb. of coal} = \text{gross calorific value per lb. of coal} - 1{,}055\ (\text{lbs. moisture} + 9 \times \text{lbs. hydrogen}).$$

The recommendation in the 1913 Code that the net (or lower) calorific value should be adopted has led to considerable confusion, and it is gratifying to know that the present Committee now propose to adopt the gross (or higher) calorific value. It is hoped that the Committee's recommendations will be quite definite on this point.

The calorific value as determined in the bomb calorimeter is, of course, the gross calorific value "as dried," and in order to obtain the gross calorific value "as fired," it is customary to correct for the percentage moisture as found in drying a sample in a drying oven. *i.e.*,

$$\text{Gross calorific value "as fired"} = \text{Gross calorific value "as dried"} \times \frac{100 - \text{per cent. moisture}}{100}$$

No doubt the Committee will deal with this moisture question in their revised Code, but it certainly seemed significant that the matter was not touched upon at their meeting on the 3rd inst.

The recommendations on the determination of the calorific value of fuel will have far-reaching effects beyond the actual carrying out of boiler trials. In fact, it is hoped they may form a satisfactory basis for the calculation of the overall thermal efficiency of power stations. At present the returns of the various electricity undertakings to the Electricity Commissioners are not comparable, owing to the fact that the calorific values are not given on the same basis in all cases. I believe a few of the larger undertakings have agreed to adopt the gross calorific value "as fired," but there is little doubt that others use the lower calorific value in some form or other, thereby showing a relatively higher overall thermal efficiency.

July 14, 1924. "THERMAL."

TO THE EDITOR OF ENGINEERING.

Sir,—As you have given in your issue of July 11 last a very considerable editorial space to the question of a revised code for Boiler Plant Testing, expecially the history of the subject, and the work of the joint committee of nine engineering societies, which we are given to understand has been considering this question since September, 1922, I want to know, if in fairness, you will allow me space in your columns to make some comments on this question, whilst apologising for the length I am asking.

I should like to give for the first time in public some facts relating to the revision of the Institution of Civil Engineers' Boiler Test Code. As is well-known I have carried out hundreds of boiler tests since about 1908, and have published the detailed results of about 300 different boiler plants and the average figures for 400. During this long experience, under all kinds of conditions, I gradually built up for myself a practical code, and finally in 1921 I offered a detailed paper to one of the most prominent engineering societies (not the "Civils") on the subject, containing the full details of a suggested International Code. I was then told I must not criticise the Institution of Civil Engineers, but must re-write the paper leaving out entirely their name. Accordingly I did so, and then after much further delay and waste of time, the paper was refused, no reason being given. Accordingly I enlarged this paper into my book, "Boiler Plant Testing," which appeared in March, 1922, and incidentally I took the opportunity to say exactly what I liked about the "Civils" Code with the name all complete. Further, I gave a paper on this subject of an International Code before the Congress du Chauffage Industrial, in Paris, July, 1923, although the present World Power Conference refused to accept a paper from me on the subject. Now until this book of mine appeared hardly a single word had been said in public against the 1913 Civils Code, although of course every practical man simply ignored it as hopeless. I state, as a simple matter of elementary fact, that it is due entirely to my publications and original work that the Civils Code has now been widely recognised to be such a disgrace that the present committee was mysteriously appointed in September, 1922.

By what right the 36 members of this joint committee usurp the authority to speak for British engineering on the intricate subject of Boiler Plant Testing is not clear, like many more things in the history of scientific societies. In the first place some of the Institutions represented have little standing in the matter, whilst one of the most important, the Institution of Chemical Engineers, has been left out.

I am not acquainted with the names of all the 36 members who are on this Committee, but of those I do know three or four are no more competent to give an opinion of value on boiler plant testing than hundreds of other engineers. As far as I am concerned it will not be much of a boast to say I have had more real practical experience of this subject than all the Civils Code Committee of 1913 put together. How any group of engineers could have produced such utter bosh, including the sampling of flue gases over mercury, the pulling down of the main steam pipes to put in antiquated so-called driers, the lower heat value for the coal, the determination of the level of each fire with a huge steel poker cut into inch notches, together with, in the middle of all this mess, the solemn reading of the barometer, presumably to two places of decimals, is beyond comprehension. I defy the 16 members of this 1913 committee to carry out an 8-hour test on an average medium-sized boiler plant, according to their own code, even if they took a month over the job. The point is, are the present Committee any better? There are in Great Britain a limited number of men, probably at the most two or three dozen, who have a profound knowledge and experience of boiler plant testing. They are to be found in the ranks of several water-tube boiler and mechanical stoker firms, consulting engineers, insurance companies, and in a limited number of power stations and large industrial plants. These are obviously the men who should be entrusted with drawing up a proper code.

With regard to the recommendation of this Committee, the mountain has, we understand, now been in labour for nearly two years, and the resulting mice include the proposed adoption of the higher calorific value for the fuel and the abolition of the expression "boiler horse-power" (!). I may say, incidentally that I introduced about 1910, the term "from and at 212 deg. F. per 1,000,000 B.Th.U." as an improvement of the stupid phrase "from and at 212 deg. F.," and the necessity for the use of the higher heat value is described in detail in my book, published months before the Committee was appointed, whilst, of course, every practical man has used this method for years.

I see also the Committee seem to be still footling about with the question of condemning steam meters and water meters, most of which are in practice much more accurate than clumsy weighing. I have never been able to understand why a number of makers of these instruments, who have had years of experience in the business, and, for example, received certificates of accuracy from the National Physical Laboratory, should continue to take lying down pompous statements of this character from people who obviously know little or nothing about the subject.

Yours,
DAVID BROWNLIE.

46, Grange-road, Ealing, London, W. 5,
July 14, 1924.

WATERLOO BRIDGE.

TO THE EDITOR OF ENGINEERING.

Sir,—What shall be the fate of Waterloo Bridge? But for the present determination of the L.C.C. about which no uncertainty is permitted, the whole matter is in a state of confusion. It has been proposed :—

1. To leave the bridge as it is—but for work of restoration. 2. To dismantle and rebuild the bridge of similar appearance, but of greater width. 3. To retain the major part of the present bridge as at present, but to throw the two faulty arches into one—with wide abutment piers. 4. To build a steel arch bridge of say, three spans, of width sufficient to accommodate tramways.

It is also proposed to build a supplementary bridge a little lower down the river.

The cost of these schemes would probably vary from say, 200,000*l.* to 1,500,000*l.* in the order 1, 3, 2, 4.

The first is ruled out at present on the advice of the L.C.C. officers and consultants. The second now holds the field, having been provisionally accepted by the L.C.C. The third has advantages but has not been publicly discussed, and the fourth is in much the same position.

"In a multitude of counsellors there is wisdom." It may be so, but has the wisdom been located? The Council as the responsible body has no choice but to accept the advice of its experts, and any person who ventures to question the wisdom of decisions reached, adopts an attitude, the implications of which are not favourable to opinions of his modesty. I am aware of this, and yet question if the right thing with respect to reconstruction is about to be done. The bridge if rebuilt with deep foundations should last many centuries longer than the River Authority may be content to put up with it. That there are defects in the existing bridge other than those clearly visible is in no sense surprising after 100 years of life. Sinking of the fourth pier (from the Surrey side) has been manifest for some 50 years and clearly must be adequately dealt with, as also that of its neighbours, but to pull down the whole bridge because of this is a very drastic proceeding. For no better reason London Bridge should be displaced, for that has been "down" near a foot on the down stream side since within a year or two of the time it was built. The Pont de Neuilly, on the outskirts of Paris, of somewhat larger spans than those at Waterloo, founded in much the same manner, has been standing since 1772, some fifty years longer than Waterloo Bridge, though freedom from tidal scour, it is true, places that bridge in a much better position. The incidence of moving loads on a heavy masonry structure may be a relatively small matter, as affecting its well being. In the case of Waterloo Bridge these loads are but 1½ per cent. of the total load at the pier base, or about 3 per cent. of the load carried by an arch. "Impact" which in a steel bridge of like span carrying steam locomotives may be that due to a live load much greater than the bridges weight, is in a structure of such great mass under road traffic practically negligible.

I make no apology for expressing views, which if not acceptable, damage no-one other than perhaps by recoil upon myself.

Yours truly,
W. H. THORPE.

12, Buckingham-street, Strand, London, W.C.2
July 10, 1924.

THE FUEL RESOURCES OF CANADA.

TO THE EDITOR OF ENGINEERING.

SIR,—I desire to direct your attention to certain errors in your report of my remarks made at two of the Sessions held in connection with the World Power Conference at Wembley. The report to which I refer is contained in your Journal of July 11 ("Proceedings of the First World Power Conference").

On page 38, bottom of column 3, your journal quotes me as saying :

1. "That the Canadian oilfields were threatening depletion and Canada wanted coal oils."

2. "Domestic fuel was a principal requisite in Ontario, and for their railway lines of 3,000 miles they could not but import anthracite."

3. "Their own coal was very friable, but the Fuel Board had erected large coke ovens and they wanted to produce fuel oils."

Again, on page 39, second column, second paragraph, from bottom, you report me as saying : "Mr. Haanel referred to the noteworthy work done in Canada where Messrs. Peco, Limited had perfected the Ekenburg process."

Taking these in their order, what I did say was :

1. That processes for heat treating fuels in general which might be eminently successful in one country might be entirely uneconomic when applied to the fuels of another country where conditions were entirely different; that each country had its own individual problems, therefore I did not desire the impression to go abroad that any carbonisation process which might be utilised successfully in Great Britain and on the European Continent could be utilised with equal success in countries such as Canada. In this connection, I stated that Canada did not possess at present any extensive oilfields; that the oilfield in Ontario of limited extent was approaching depletion and that any method, therefore, which could successfully convert, partially, solid fuels into oils suitable for motor and other purposes would be of great importance to Canada.

As in my paper, which was so excellently epitomised in your journal, I emphasised the fact that if motor oils could not be supplied regularly and in increasing quantities, the result, so far as the extensive motor manufacturing industries and those dependent on them are concerned, would be of a most serious nature.

2. I said, further, that the Provinces of Ontario and Quebec have no economic coal measures, and were too remote from the Western coalfields to take advantage of the immense coal resources there, that is, at present. Therefore, the principal consideration in this, the most highly industrialised and populous section of the Dominion, was an assured supply of a domestic fuel and a fuel for power purposes. This section of Canada, I pointed out, while it did not possess coal measures, did have enormous areas of peat suitable for the manufacture of a domestic and, for some purposes,

an industrial fuel, strategically situated with respect to manufacturing centres, inhabited communities and transportation facilities, and in order to ascertain whether this low grade fuel could be economically manufactured into a domestic fuel the Dominion Government and the Governmnet of the Province of Ontario jointly appointed a Peat Committee, of which I am a member and Honorary secretary, to conduct an exhaustive investigation concerning ways and means for developing these large peat areas. I said that, as a result of five years' work, we had succeeded in developing machinery which reduced manual labour, it was necessary to employ, to a minimum and made possible the manufacture of peat fuel on a commercial basis at a cost of $3·50 per ton of 30 per cent. moisture, peat fuel F.O.B. cars plant siding.

Regarding coal, I made the statement that the Dominion Fuel Board, of which I am a member, engaged an expert engineer to conduct an investigation, the objective of which was to ascertain the feasibility of establishing by-product recovery coke oven plants at strategic points in the provinces of Ontario and Quebec, for the manufacture of a domestic fuel to replace anthracite now imported, and a domestic gas equal, if not superior, to the retort gas now manufactured, such plants to be operated on Canadian coals as far as possible. I pointed out that if such plants were erected the quantity of anthracite now annually imported for domestic use, and also the high-grade gas coals which are imported from outside sources, and amount annually to 650,000 short tons, would be materially reduced.

The railways of Canada do not burn anthracite coal. In this connection I pointed out that the railways of Canada depended very largely upon imported steam coals for operating their locomotives in the Provinces of Ontario and Quebec, and in those traversing the Prairie Provinces where lignitic coals abound. I drew attention to the great economies which might be effected if it were found possible to economically burn the low-grade coals of these sections in the locomotives in the powdered form, and said that the Dominion Fuel Board was now undertaking an investigation to ascertain the value which such method for burning coal would be to our railways.

3. This item is partially explained above. I may, however, add that I made the statement that Canadian lignites disintegrated on exposure to the weather, finally passing into a finely divided state, and since this was the natural state into which they passed, after being mined, it would appear that the proper manner for burning them would be in the powdered form.

I wish to state emphatically that the Canadian Government and the Dominion Fuel Board *are not* erecting coke ovens or any other industrial plants. The function of the Dominion Fuel Board and other Boards, of a similar character, appointed by the Dominion Government is merely that of conducting nvestigations and educational campaigns.

Re Peat.—In regard to my remarks on Professor Purcell's paper, I made the statement that Professor Purcell was performing for the British Fuel Research Board investigations similar to those which I am conducting for the Canadian Department of Mines, and that I most emphatically endorsed his opinion "that the only economic process known to-day for manufacturing peat fuel is 'the air-dried machine peat process'" I remarked that the Ekenburg process, on which several millions had been expended in this country, had proved a failure, and that although the Peco, Limited, were attempting to improve that process I, personally, was of the opinion that they had no chance of developing an economic process. Messrs. Peco, Limited, so far as I know, never attempted any work in Canada in connection with peat.

Will you, Sir, be good enough to carefully note my comments and make the necessary corrections at the earliest date possible.

Yours faithfully,
B. F. HAANEL.

c./o. The High Commissioner for Canada, Kinnaird House, Pall Mall, S.W. 1.
July 13, 1924.

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LIMITED.—On account of lack of support, this society has decided to abandon the tractor trials which were to have been held during September, at Harmondsworth.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—The Fifth Annual Dinner of this Institute will take place on Thursday, the 24th inst., at 7 p.m. for 7.30 p.m. The costing conference will be held on Friday, the 25th inst., the morning session at 11, when the subject will be "Administration and Selling Costs, their Nature and Distribution"; the afternoon session at 2.45, the subject being "The Function of Costing in Industrial Relations." Both the dinner and conference will be held at the Connaught Rooms, Great Queen Street, W.C., and Viscount Leverhulme will preside.

INDUSTRIAL NOTES.

THE Miners' Federation of Great Britain, at their meeting in Swansea last week, passed unanimously a resolution instructing the Executive to continue to press for membership of the Federation being a condition of employment at the collieries. Another resolution was passed stating that the time had arrived when a universal day wage should be established in all mines, also one asking the Executive to endeavour to have a Commission set up by Government to inquire into safety appliances in mines. Mr. Robert Smillie, M.P., moved "That the Conference reaffirms the principle that nothing short of the nationalisation of mines and minerals of this country will be a satisfactory solution of the mining problem, and requests the Executive to take every means possible to further this principle and to have it placed upon the Statute Book." This resolution was accepted, also one to the effect that the Federation take definite steps to secure a fortnight's annual holiday with pay for all workmen engaged in and about the coal mines. A resolution moving that the time was opportune to seek an amendment of the Mines Seven Hours Act without any reduction in wages was carried, also one for establishing a five-day working week. A resolution calling upon the General Council of the Trades Union Congress to convene a National Congress to consider the fixing of a minimum wage for all workers, sufficient to bring them above the poverty line as laid down by Sir Leo Chiozza Money was adopted without discussion.

At the concluding sitting a resolution was passed expressing the disappointment of the Conference with the Workmen's Compensation Act, 1923. The mover said they had hoped that the Act would have swept away many of the injustices and anomalies of the old compensation law, but with the exception of the higher payment in cases of fatal accidents the new Act was reactionary rather than progressive. It was urged that the compensation to be paid should be equal to a man's full wage, because if there was a time when a man needed the money it was when he was disabled by an accident. The Executive were instructed to formulate a scheme of superannuation for all miners on attaining the age of 60, the cost of the scheme to be a charge on the industry. The scheme, it was urged, would result in occupation being found for youth's leaving school, enabling them to earn money to help their parents at home.

At a private meeting it was proposed that steps be taken to form an alliance with the National Union of Railwaymen, the Transport Workers' Federation, and any other union where practicable. This point is to be considered further by the Executive, and will be gone into at the Trades Union Congress at Hull, in September.

The National Union of Railwaymen continued their sitting last week at York and passed the following resolution:—"This Congress endorses the action of the Executive Committee in placing upon the agenda of the forthcoming International Transport Workers' Federation Conference at Hamburg, the resolution of protest against the general application of the terms of the Washington Hours Convention. We regret that no provision has been made to exclude railwaymen from the application of the Hours of Employment Bill. We affirm that any attempt to enforce the conditions there laid down would meet with the united resistance of members of the National Union of Railwaymen, inasmuch as they would take away the guaranteed day and guaranteed week, independent of Sunday working, and also the concession of each day standing by itself for the purpose of calculating overtime." A further motion was: "That this Congress, having reviewed the working of the railways since the grouping into four companies, welcomes the same as a step towards the complete unification of the railway under national ownership and joint control by railway workers." It was referred back to the Standing Orders Committee for re-drafting. As re-drafted, the motion reads as follows:—"This Congress welcomes the grouping of the railway companies into four groups as a step in the right direction, and decides to call on the Executive of the Union to frame a Bill to be submitted to Parliament, having for its object the nationalisation and democratic control of the railways." This was carried by a large majority.

At the last sitting on the 12th inst., Mr. W. Dobbie, Labour Lord Mayor of York, was elected president of the National Union of Railwaymen, to succeed Mr. J. Marchbank, who held the office for three successive years. Mr. C. T. Cramp, the industrial secretary of the Union, stated that in a week or two the Union would formulate a new national programme of wages; he did not know what the programme would be because it would be framed by the rank and file through their elected representatives. He hoped that a part of the national programme would include pensions for all railwaymen. He added that if nothing occurred the Union would have a reserve fund of about 2,000,000*l.* by the end of the year. A recommendation of the Executive to the effect that the Union should affiliate to the National Transport Workers' Federation on the basis of that section of the membership not covered by settlements made by the N.U.R., was adopted. This decision meant that the Union would affiliate on behalf of approximately 3,000 members, including coal tippers, trimmers, and railway dock workers coming under the Shaw Dockers' Award.

The building dispute remains unsettled. The employers' Disputes' Committee decided further to suspend the lock-out notices, owing to the delay in the publication of the Court of Enquiry's findings. In the meantime, the men's representatives are reported to have decided to demand better terms than those which were accepted on June 16.

The findings of the Court of Enquiry were issued on Wednesday evening and were unanimous. They state that the immediate causes of the dispute were the following:—"A claim for increased wages on the part of the operatives. The refusal of large bodies of the operatives to carry out the award of Sir Hugh Fraser with regard to working hours in the summer. The belief that the employers had attempted to obstruct the free working of local arrangements by which the extra hours in summer might be avoided. The Liverpool dispute. Each of these circumstances was a contributory factor and entered into the final dispute, but all were included in the agreement of June 16, and, had it not been for the Liverpool position, would have been adjusted. The main cause of the cessation of work is the refusal of the Liverpool operatives to accept the special terms of the settlement offered to them on June 10, and to submit to the decisions of the National Wages and Conditions Council. The resulting issue has been productive of much misunderstanding between the parties. Recognition by each side of the fact that their position has not been understood by the other, the settlement of the Liverpool difficulty and the resumption of negotiations appear to be the only means by which the dispute can be brought to a speedy end, and good will restored in an industry of national importance and owing great responsibility to all classes of the public."

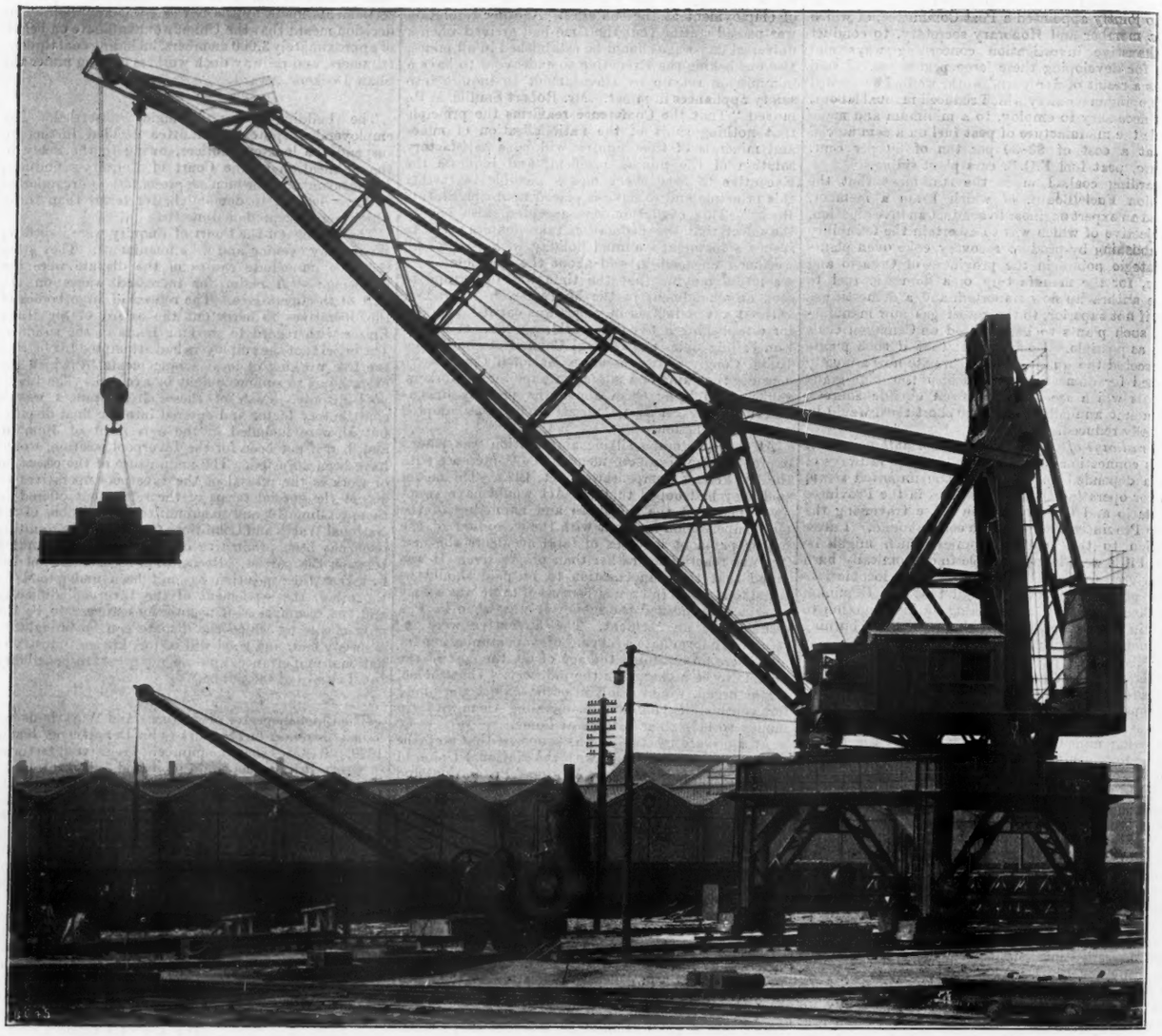
The Chief Inspector of Factories and Workshops has issued his report on the work of his Department during 1923. It states that the number of registered factories in Great Britain has again increased. The total now stands at 139,920, as against 137,858 in 1922. Workshops declined from 145,684 to 140,850. The decrease in the number of workshops has been going on steadily for a number of years, and is largely due to the introduction of power which immediately brings the workshops under the classification of factories. There has also been a steady closing up of small workshops, mostly in rural areas. During the year under review 125,551 accidents, including 867 fatal, were reported, an increase of 27,565 over the previous year. In general, the hours of work appear to be kept well within the legal limits. Women have returned to women's industries, and very few are now to be found even in those sections of men's trades for which wartime observation and experience showed them to be peculiarly well fitted. The use of electrical energy in factory premises for power, lighting and other special purposes continues to extend rapidly, and, as a consequence, the capacity of the generating stations is constantly being increased.

Following our note in our last issue referring to the engineering unions' application for an all-round increase in wages of 1*l.* per week, and announcing that a joint conference would be held on Wednesday, the 16th inst., we are informed that the claim was considered at this conference and was refused by the employers, who made no counter-proposal. The men maintain their claim; the union representatives are to report to their executives, and a conference of the unions is to be held on the 31st inst. to receive the reports of the executives.

THE MANGAHAO POWER SCHEME, NEW ZEALAND.—H.M. Trade Commissioner at Wellington reports that the Public Works Department, New Zealand, are calling for tenders for the supply of 11,000 volt switchgear and metering for the Mangahao power scheme. Tenders will be received up to September 2 by the Secretary, Public Works Supplies and Tenders Committee, Government Buildings, Wellington. A copy of the specification and general conditions of tender is available for inspection by United Kingdom firms at the Department of Overseas Trade (Room 52), 35, Old Queen-street, London, S.W.1. The Public Works Department are also calling for tenders for the supply of transformers for the same scheme. Tenders will also be received up to September 2. Copies of the specification and general conditions of tender are available at the same offices.

25-TON ELECTRIC LEVEL-LUFFING CRANE; CONGELLA GRAVING DOCK, DURBAN.

CONSTRUCTED BY MESSRS. SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.



25-TON ELECTRIC LEVEL-LUFFING CRANE.

A 25-TON crane forming part of the equipment of the Congella Graving Dock at Durban, and manufactured by Sir William Arrol and Co., Limited, Glasgow, for the Union of South Africa, is illustrated in the half-tone engraving on this page.

The crane is fitted with horizontal luffing gear, and is capable of lifting, derricking, and slewing round a complete circle with a maximum load of 25 tons, each motion being operated by a separate motor. The leading particulars are as follows: Maximum radius from centre of track for 25-ton load, 90 ft.; maximum radius for 10-ton load, 100 ft.; minimum radius, 40 ft. The crane hook has a range from 52 ft. below rail level to 80 ft. above rail level. The gauge of track rails is 26 ft., and the track will be formed with 80 lb. B.S.S. flat-bottomed rails bolted side by side.

The speeds of working are: Lifting 25 tons at 20 ft. per minute, lifting 10 tons at 50 ft. per minute, and smaller loads at increased speeds; slewing 25 tons, 1 revolution in 3 minutes; derricking 25 tons, 6 ft. per minute; travelling 25 tons, 60 ft. per minute.

The gantry, as will be seen from the illustration, is built up of rolled-steel sections and plates well gusseted, braced, and riveted together. The underside of the gantry is 14 ft. above rail level. The superstructure revolves round a forged-steel centre pin on cast-steel rollers, running on a steel roller-path securely attached to the top of the gantry. The load is lifted on steel-wire rope, and the hoisting motion is fitted with change-speed gears in order to give the specified speeds of lifting. The derricking gears operate in such a manner that the load is derricked in and out horizontally. The derricking motion is controlled by an automatic solenoid-operated brake, and an automatic thrust brake is fitted, capable of holding the jib in any position.

The electric supply is three-phase, 50 cycles, 400 volts, and the motors are of the totally enclosed slip-ring reversing type, the controllers being of the drum-reversing type. A totally enclosed self-resetting limit switch is fitted to the hoisting motion to prevent over-winding, and similar switches are fitted to the derricking gear to limit the range of the jib. The crane was tested under all motions at Sir Wm. Arrol and Co.'s Parkhead Crane Works. The firm has under construction a similar crane, but of 10 tons lifting power, for the same dock.

PERSONAL.—Mr. G. H. Baillie, Consulting Engineer, states that following on Mr. A. Dobrée's retirement, he is continuing the business of the firm of Baillie and Dobrée, as from the 7th instant, under his own name, at Windsor House, Victoria-street, Westminster, S.W.1 —On June 27 a meeting of the staff was held at the Consultative Branch of the Board of Trade to take farewell of the Principal Surveyor for Tonnage, Mr. T. F. Jenkins, who was voluntarily relinquishing his duties after 34 years' service on the Board. A gold watch and chain was presented to him.—The permanent address of the Engineering Association of Malaya is now No. 1, Old Market-square, Kuala Lumpur, Federated Malay States.—Mr. Andrew S. Macharg, C.A., has joined the Board of Directors of the Scottish Tube Company, Limited. Mr. Macharg is one of the senior partners of Messrs. McClelland, Ker and Co., Chartered Accountants, Glasgow.

THE KELVIN CENTENARY CELEBRATIONS.—The Kelvin Centenary Celebrations, referred to elsewhere in this issue, concluded on Friday, the 11th inst., with a banquet held at the Connaught Rooms, the Rt. Hon. the Earl of Balfour taking the chair. After the loyal toasts had been duly honoured, Lord Balfour proposed the toast in memory of Lord Kelvin. Lord Balfour referred particularly to the fact that Lord Kelvin was not only a great man of science but a great inventor who had an instinctive knowledge of the way in which physical discovery would lead to industrial progress; he was, Lord Balfour added, a practical inventor of machines which paid. It was, however, as a man of science that he was, and should be, chiefly honoured. Lord Kelvin, the speaker continued, in laying down the Professorship at Glasgow University which he had held for 50 years, had used the word "failure" in referring to his career, but the scientific historian looking back on the century, the close of which was being celebrated, would assuredly say that the man who had contributed as much as any-one else to the triumphs of science in that period was Lord Kelvin. The toast of the "Delegates to the Kelvin Centenary" was proposed by Sir Richard Glazebrook and responded to by Dr. Elihu Thomson and Professor Luigi Lombardi, the delegate of the Real Accademia Nazionale dei Lincei, Rome. Dr. A. E. Kennelly proposed the toast of the Chairman. About 350 guests were present, including many eminent scientists and engineers, and the gathering was, in all respects, a fitting termination to the Celebration proceedings.

HOT-BULB AND HIGH COMPRESSION ENGINES IN SWEDEN.*

By GUNNAR DELLNER, Diesels Motorer, Atlas-Diesel Co., Stockholm.

THE most important engines in the Swedish internal combustion engine industry, especially in the case of smaller sets, are those of the hot bulb type, which for a number of years have formed the principal export from Sweden, as far as internal combustion engines are concerned. Among Swedish makes well known in the world's markets are those of "Bolinder," "Skandia," "Avance," "Munktell" and "Atlas." In Sweden, hot-bulb engines have been used a good deal in the smaller industries and in agriculture; but they have been taken up especially in the fishing trade, and it can be said without exaggeration that practically the whole of the Swedish fishing fleet, with the exception of large-sized trawlers, is now equipped with oil engines. Thanks to the experience gained from these fishing boats, the marine engines have been developed to the height of technical perfection. In the construction of hot-bulb engines, it has always been considered important to produce as simple and reliable an engine as possible, which can be managed without difficulty by relatively unskilled engine drivers. The Swedish hot-bulb engine industry has, therefore, in its designs, generally adopted the two-cycle principle, the scavenging of the working cylinders taking place by means of air, compressed in the crank case. In the early days the engines were generally provided with water injection in the working cylinders, in order to prevent overheating at heavy loads. The complication of the engine involved by water injection compelled the manufacturers, however, to make energetic efforts to eliminate this device from their designs, and there are now only a few works still retaining it. The fuel spray has, as a rule, been made adjustable on all engines where water injection has been eliminated, whereby the advantage is obtained that, at heavy load, less heat and, at light load, more heat is supplied to the "hot-bulb." Simultaneously with the elimination of water injection, the compression pressure has generally been increased, enabling the dimensions of the hot bulbs to be reduced, which is of importance.

With a view to simplifying still more the management of hot-bulb engines, several new methods of starting have been introduced. Amongst others, a leading firm (Bolinders) have availed themselves of an ignition device in the "hot-bulb" heated by means of current from a small electric battery charged by a generator driven by the main engine. The engine is thus always ready for starting and can furthermore be started almost immediately. Several other firms have fitted their engines with so-called quick starting lamps, which are designed for burning crude oil and can be ignited without previous heating.

In order to improve the mechanical efficiency, some firms have fitted ball bearings in the main bearings of their engines. These bearings have, however, so far not become very popular, although they have certain points in their favour, at least in the case of single cylinder engines where the bearings are easily accessible for overhauling.

On the whole, it must be admitted that the progress in the hot-bulb engine industry has reached such a stage in technical development that only small alterations in details have been made during the last years. No actually new constructions in this line have thus been made as far as the more important parts are concerned. The economical crisis which since the year 1920 has affected the Swedish industry, and the effects of which are still felt, has, no doubt, also to a certain extent prevented the introduction of new designs.

Parallel with hot-bulb engines, high compression engines are now beginning to find a market for installations where hitherto hot-bulb engines have exclusively been used. Among engines with cold starting system produced in Sweden, and which have found the greatest market, are the "Ellwe" and "Polar" engines. These machines are both built as vertical engines and work on the two-cycle system with scavenging from the crank case. As far as the system of ignition is concerned, they are, however, quite different. The "Ellwe" engine, which is manufactured by Svenska Maskinverken, Södertälje, works with what is termed a pre-explosion chamber in which a bushing is placed, serving as gasifier. Part of the fuel burns in the pre-explosion chamber, thereby producing gases with high pressure which, together with unburned oil, are forced into the cylinder chamber where the final combustion takes place. A special ignition cartridge, consisting of blotting paper impregnated with nitrate of potash, is ignited and put into the pre-explosion chamber before the starting air is introduced. Combustion is thus started and afterwards the heat produced by means of compression is sufficient to cause ignition during running.

The "Polar" high compression engine is more similar to the ordinary Diesel engine. It is manufactured by the Atlas-Diesel Company, Stockholm, who, for about 25 years, have manufactured Diesel engines both of marine and stationary types and, furthermore, during recent years have specialised on Diesel engines for locomotives and auxiliary engines for vessels. On th "Polar" high compression engines, the fuel is injected direct into the working cylinder's combustion chamber by means of the fuel pump and is finely atomised by a one-hole atomiser of special construction. As in the case of Diesel engines, ignition takes place due to the heat produced by compression and special means for obtaining combustion at the start are therefore unnecessary. On 1-cylinder and 2-cylinder engines the fuel pump is placed in close proximity to the atomiser. On engines with more than two cylinders the fuel pump is mounted on the engine crank case and driven direct from the crank shaft.

The Swedish high compression engines mentioned above have a fuel consumption of about 0·44 lb. per brake horse-power per hour, and the larger types even less. On account of their comparatively high speed the engines can be built relatively light, the weight being about the same as for ordinary hot-bulb engines of corresponding size. The manufacturing costs should be somewhat higher than for hot-bulb engines, due to the more careful work necessary in the manufacture of the fuel pumps and governing devices. As far as adjustability is concerned, the high compression engines are comparable with the Diesel engines and as, furthermore, the simplicity of their construction makes it possible for relatively unskilled operators to manage the engines, it should not be long before these engines supplant, to a large extent, the ordinary hot-bulb engines. Undoubtedly, high compression engines will also find a market where petrol engines have so far exclusively been used. This especially refers to such cases where great consideration must be taken to the engine's fuel economy, as, for instance, for lorries, omnibuses and tractors. The development in this direction will, of course, to a certain extent depend on how the power transmission between the engine and the driven wheels is to be carried out. If the question of power transmission can be solved in such a way that the engine can work as nearly as possible at constant revolutions there will be no technical difficulties in the way of substituting high compression engines in the place of petrol engines. It will not be difficult to increase the number of revolutions of the high compression engines to figures usual for petrol engines, and the weight of a high compression engine should only very slightly exceed the weight of a petrol engine with the same number of revolutions.

* Paper contributed to Section E of the World Power Conference, on July 8, 1924.

LARGE GAS ENGINES IN GERMAN POWER ECONOMY.*

By PAUL R. MEYER, Nürnberg.

THE great success of the large gas engine started only after it had become possible to build a reliable double-acting four-cycle engine by making extensive use of the experience gained in the construction of large steam engines. The leaders of the large German iron and steel works favoured in a very broadminded manner the introduction of this new prime mover and did not lose courage on account of the first difficulties which had to be overcome.

Large German gas engines are without exception of the horizontal type and work according to the two-cycle, as well as the four-cycle principle.

Two-cycle Gas Engines.—At present only the Koerting type is built and used especially for driving blowers. The cylindrical heads are now divided into inner part and cooling jacket and strengthened by shrink fits which improves the reliability of these parts in such a way that failures have become rare. A separately-driven gas inlet valve reduces the gas losses to a minimum. The engines are of the single-cylinder and also twin-cylinder type. The tandem arrangement is possible, but requires rather heavy driving-gear.

Some years ago there was built an engine which represents practically a double-acting Oechelhæuser engine. This type has two closed working cylinders arranged beside each other and double-acting pistons, the rods of which are coupled to a common cross-head. The combustion chambers of the two cylinders communicate at both ends. The distribution ports lying in the middle of the cylinders serve in the one-cylinder for exhaust and in the other one as inlet for air and gas. As special inlet valves are avoided with this type, leaving only the charging pumps to be mechanically governed, the engine has a very neat appearance. It is also claimed to run at a higher speed than normal two-cycle engines, making it therefore especially suitable for driving dynamos. An engine of this make has run with good results for several years.

Four-cycle Gas Engines.—With regard to four-stroke engines, the well-known Nürnberg design has been accepted as standard for general arrangement. The cylinders are of the one-part and also the multiple-part type, the latter being used especially for larger dimensions, and provided with hard cylinder liners. The admission gear, consisting formerly of two valves, the mixture valve and the admission valve, is replaced nowadays by one valve only combining the admission and mixing functions. Governing is performed mainly by influencing the quantity of fuel mixture, the composition of which is not materially changed. This is attained by altering the valve lift or the adjustment of throttle valves into inlet pipes for gas and air. The engines are of the tandem type with two cylinders or of the twin-tandem type working with four cylinders.

Total Output and Capacity.—The total output of large gas engines built in Germany up to 1923 amounts to 370,000 b.h.p. for the two-cycle type, and 2,230,000 b.h.p. for the four-cycle type, making a total of 2,600,000 b.h.p. Of this, about 2,000,000 b.h.p. have been installed in Germany and about 600,000 b.h.p. in foreign countries. The capacity of normally working units ranges between 500 and 8,000 b.h.p. Engines of less than 1,000 b.h.p. are very rarely met with. In the first few years the mean indicated pressure went up as far as 5·3 kg. per square centimetre (75 lb. per square inch), applying at the same time a rather high compression. However, the excessive explosion pressures occurring now and then proved to be unfavourable with regard to the reliability of the engine parts. Therefore it has been the general tendency in practice in recent years to return to a moderate compression and to a mean indicated pressure of about 4·5 kg. per square centimetre (65 lb. per square inch).

Fig. 1.

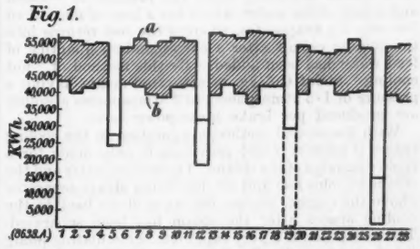


FIG. 1. Additional output of a large gas engine with scavenging and supercharging (*a*), compared with a normal engine of same size (*b*).

Increase of Output.—The requirements of the power consumers and the competition with the steam turbine called, however, for still larger units. It was found that even the output of the large four-cycle engine could be considerably increased in a rather simple way without submitting the engine to higher stresses than hitherto, viz., by the scavenging and supercharging process.

The burnt gases remaining in the cylinder at the end of the exhaust stroke are scavenged by means of compressed air of 0·2 atmosphere to 0·3 atmosphere above atmosphere (3 lb. to 4 lb. per square inch). Towards the end of the following suction stroke some more compressed air is admitted, and mixes with the sucked charge having an excess of gas. The compression space is thereby fully utilised for the charge and the temperature of the sucked mixture reduced. Corresponding to the increased weight of the charge, the average indicated pressure rises to 6·5 atmospheres (90 lb. per square inch) and more, resulting in an increase of the normal output by 20 per cent. to 40 per cent. Working in this way the largest engine unit with four cylinders has a capacity of about 12,000 brake horse-power. Fig. 1 shows the difference of output of two engines of the same dimensions, one (*b*) running normally, the other (*a*) with scavenging system. In order not to endanger the engine in spite of the higher average pressure, the compression space is so much enlarged as to avoid undesirably high maximum explosion pressures. Some alterations at the inlet valves and the installation of a supply piping for the compressed air, supplied usually by a turbo-blower, are about the only differences compared with a normal gas engine. The scavenging and supercharging, of course, can be dropped or taken up at any time automatically or by simple hand operation, the engine thus running under normal conditions or with supercharge respectively.

Waste Heat Recuperation.—Together with the endeavours to increase the capacity an attempt was made to improve the specific output from a given amount of fuel, *i.e.*, the thermal efficiency. The losses due to the heat carried away with the cooling water and the exhaust gases can be reduced to a great extent if this heat be successfully recovered in a suitable form.

* Paper, abridged, contributed to Section E of the World Power Conference on July 8, 1924.

The exhaust gases leave the gas engine with a temperature from of 400 to 700 deg. C. These temperatures allow the economical generation of highly superheated steam up to a pressure of 20 atmospheres (285 lb. per square inch).

Hardly any gas engine is installed at present in Germany without a waste heat boiler. These recuperators are all of the closed tubular-boiler type, the tube set of which is withdrawable in order to facilitate cleaning on the water side. An economiser built on the same principles is usually arranged above the boiler, and a superheater is provided between engine and boiler. The whole plant is constructed in such a manner that any explosions which might occur in the exhaust piping due to unburnt gases have no detrimental effect. By means of such waste heat boilers the exhaust gases are cooled down to from 150 deg. to 200 deg. C., producing at the same time about 1 kg. of steam of usually 12 to 15 atmospheres and 300 deg. to 400 deg. C. superheat per brake horse-power/hour.

Pressure Hot Cooling and Evaporation Cooling.—The great heat losses by cooling water indicated also possibilities for improvement. As long as the cooling water was discharged at a low temperature an economic recovery of the lost heat was nearly impossible. The cooling water temperature had to be raised, therefore, as high as this could be done without losing control of regular running and without jeopardising the engine. This task was taken up from two sides. With the one method the cooling water is put under so high a pressure that no evaporation can take place in the cooling spaces. In a special collecting boiler the pressure is reduced and a part of the water, which has a heat of more than 100 deg. C., evaporates, whereas the rest returns into the cooling circuit after a corresponding quantity of feed water has been added. By this method of "hot cooling" about 0·6 kg. of saturated steam having a pressure of 1·5 atmospheres to 2 atmospheres absolute are produced per brake horse-power/hour.

With the second method evaporation in the cooling spaces is permitted and provision is only made for a rapid discharge of the steam. The cooling water and the steam bubbles rise and are led into a steam separator above the engine, whence the water flows back to the cooling spaces after the steam has been separated. The circulation is a very rapid one, a circulating pump being superseded. By this method about 0·6 kg. of saturated steam of 6 atmospheres absolute pressure (85 lb. per square inch) is produced per brake horse-power/hour of the gas engine. It can be used according to its application, either directly or, after passing it through a superheater, in dry state.

Fig. 2 represents the scheme of the waste-heat recovery of a large gas engine. The generated steam is utilised in a mixed pressure turbine ("Erste Brünner" system), yielding additionally 0·36 h.p. for each horse-power of the gas engine.

In a modern four-cycle engine a heat consumption of 2,400 calories per brake horse-power hour is not exceeded, assuming a load of 70 per cent. or more.

The thermal efficiency of the gas power plant with waste heat recovery amounts therefore to

$$\eta_{therm} = \frac{1 \cdot 36 \times 632}{2{,}400 \times 100} = 36 \text{ per cent.}$$

In many cases, as for example in most metallurgical works, collieries and large chemical works, an extensive steam plant is in operation besides the gas engines. The steam generated by the gas engine plant replaces in such a case a corresponding part of steam produced formerly in direct fired boilers. The gas engine plant supplies steam to the steam engine plant and receives in exchange the fuel used hitherto for generating this steam, either actually in the form of gas, or by crediting the fuel value.

In addition to the gas burnt hitherto in the steam plant extra gas to an amount of only 1,150 calories per brake horse-power hour has to be supplied to the gas engine. This corresponds to a heat efficiency of

$$\eta_h = \frac{632}{1{,}150 \times 100} = 55 \text{ per cent.}$$

It is unnecessary to say that in case of utilising the waste heat for bathing, heating and boiling purposes the efficiency is considerably higher and can rise in the given example to 80 per cent.

Let us presume that the thermal efficiency of a large high pressure steam turbine plant of the most up-to-date design for a steam pressure of about 40 atmospheres (570 lb. per sq. in.) and a temperature of 540 deg. C. superheat is

$$\eta_{therm\,t} = 28 \text{ per cent.}$$

It will be recognised that an up-to-date gas engine plant has an efficiency which is at least one-third higher from a thermal point of view.

Financial Economy.—In the Table annexed the total cost of power, using gas engines and steam turbines, is given for a blast furnace plant of a capacity of 1,000 tons of pig iron per day, working in conjunction with an adequate coking plant. The prices are in accordance with those of the German market on April 1, 1924. The gas engine plant is compared with an up-to-date steam turbine plant ("Erste Brünner" system), for highly superheated high-pressure steam. For both plants a total load factor of 70 per cent. is assumed.

From the quantity of gas and small coke available for power purposes there can be generated 75,000 b.h.p. with the gas engine plant, and 51,700 b.h.p. with the steam turbine plant. The total cost of power production would amount in the respective cases to 1,135 pfennig per b.h.p.-hour, and 1,435 pfennig per b.h.p.-hour, and, in the case of gas engines, about 50 per cent. more current is generated from the gas than with steam turbines. On the other hand, the cost price per power unit with steam turbines is about 26 per cent. higher.

If electric current is supplied to the other branches of the works or to outside consumers, charging only the cost price of turbine-generated current, a profit of 1,800,000 marks per year is realised with gas-engine drive, which would redeem the plant in half the time

Fig. 2.

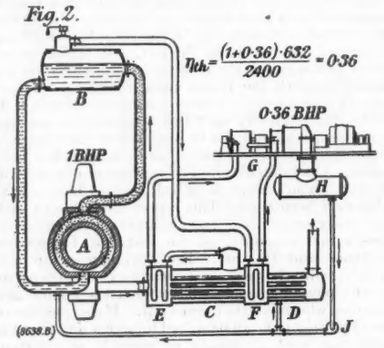


Fig. 2. Diagram of a large gas engine plant with waste heat recuperation from cooling water and exhaust. A. Gas engine. B. Steam separator. C. Waste heat boiler. D. Economiser. E. High-pressure superheater. F. Intermediate-pressure superheater. G. Mixed pressure turbo-generator. H. Condenser. J. Feed water pump.

TABLE.—*Comparison of a Gas Engine and a Steam Turbine Plant for the Same Quantity of Fuel. 70 per cent. Load Factor.*

Gas Engine Plant for 75,000 b.h.p. continuous output.	M	*Steam Turbine Plant* for 51,700 b.h.p. continuous output.	M
5 Gas dynamos DTZ 15, each for 10,000 b.h.p. 3 Gas dynamos DT 15, each for 5,000 b.h.p. 3 Gas-blowing engines DTG 15, each for 3,200 b.h.p. 3 Turbo-dynamos 7,000 kw. each, 10,000 b.h.p. All auxiliary machinery, gas-cleaning plant Small-coke gas producer, travelling crane Foundations, freight, erection, &c.	13,000,000	11 Gas-fired boilers with divided headers 1 travelling grate boiler 4 turbo-dynamos, 11,000 kw. each (16,000 b.h.p.) 3 turbo-blowers, each 3,500 b.h.p. All accessories .. Travelling crane .. Foundations .. Freight, erection,	7,500,000
Buildings ..	1,800,000	Buildings ..	1,000,000
Installed 105,000 b.h.p.	14,800,000	Installed 74,500 b.h.p.	8,500,000
Depreciation, interest: 14 p.c. for engine equipment, &c.	1,820,000		1,050,000
6 p.c. for buildings	108,000		60,000
Attendance, supervision (labour)	180,000		150,000
Lubricants	162,000		20,000
Cost of fuel ..	5,200,000		5,200,000
Cost per year (75,000 b.h.p. × 8,760 hours)	7,470,000	Cost per year (51,700 b.h.p. × 8,760 hours)	6,480,000
1 b.h.p.-hour ..	1·135 Pfg.	1 b.h.p.-hour ..	1·435 Pfg.

$$\frac{1 \cdot 435}{1 \cdot 135} = 1 \cdot 264$$

when used as additional amortisation. These figures hold good for works to be newly erected. If the plant is intended as extension of already existing works in which also large steam plants are in service, a gas engine enlargement would yield about 110,000 b.h.p. compared with 52,000 b.h.p. yielded by steam turbine addition.

Compared with the steam turbine the large gas engine remains therefore even at present the most economical prime mover for new plants or for the extension of those using gas for power-generating purposes and which rely upon a high-load factor.

Fields of Application.—The greater number of large gas engines are installed in steel and iron works and generate electric current or supply blast for blast furnaces and steel works. In some cases these engines are used also as prime movers for rolling mills, compressors and pumps. Usually carefully cleaned blast-furnace gas is used as fuel and in some exceptional cases also coke-oven gas or coke-producer gas. A considerable number of gas engines have been installed also in collieries, where they are running on coke-oven gas or coke-producer gas. In most cases electricity is generated. Lately air compressors with gas engine drive have been coming more into favour.

The extent to which large gas engines have found their way into large chemical works may be seen from the fact that an important factory of this kind has installed gas engines aggregating 38,000 b.h.p. alongside of 50,000 b.h.p. supplied by steam engines and steam turbines. Another works has installed gas engines with an aggregate output of 20,000 b.h.p. The engines generate electric current or drive high pressure compressors. As fuel, producer-gas, or waste gas from chemical processes are used. In these works the gas engines proved to be so reliable and efficient that it is intended to use them to a much larger extent as soon as a reliable and economical gasification of raw brown coal is feasible. In the paper industry this type of prime mover has likewise stood the test with great success, especially in those cases where they are driving pulp grinders or electric generators for electrolytic processes and running continuously on high load. Producer gas from brown coal briquettes has been used advantageously in these plants.

The gas engine is the ideal prime mover above all in such cases where high load is continuously to be reckoned with, *i.e.*, where the cost of fuel is of greater importance than the capital outlay.

ERSKINE HEAP SWITCHGEAR.

WE have already mentioned that the electrical switchgear exhibits at the British Empire Exhibition well illustrate the growing appreciation of the draw-out truck type of gear. This has so far come into most extensive use for panels of moderate power and voltage, which are called for in large numbers, particularly in connection with sub-station work on 6,600 and 11,000 standard voltage systems. The general features of panels of this class will be familiar to most of those who are interested in electrical switchgear, but none the less the excellent example which is to be seen on the stand of Messrs. Erskine, Heap & Co., Limited, of Caroline-street, Broughton, Manchester, may well be viewed by anyone concerned with the use of electric power. This gear, which is illustrated in Figs. 1 and 2 opposite, is a well-made example of workmanlike design, which clearly illustrates the special advantages of this class of construction.

The panel is built of ironwork throughout, and the truck portion carries a three-phase oil circuit-breaker and potential and current transformers for the instruments and trip coils. A diagram of connections is given in Fig. 3. The truck is mounted on ball-bearing wheels, and may very easily be pulled out of the fixed cubicle part of the gear by means of the two handles on the front panel. The bus-bars are carried on porcelain insulators on the back of the fixed part of the gear, and are separated from each other by insulating shelves. The back part of the truck carries further porcelain insulators at the back of which copper blade contacts are carried which make connection with fixed contacts on the bus-bars. Connection is made from the bus-bars to the oil switch through these contacts, the actual connections from the shanks of these contacts to the oil circuit-breaker terminals not, however, being indicated in the figure. The outgoing cables from the panel are connected to contacts on a row of insulators carried below the bus-bar insulators as shown in Fig. 2. These insulators carry further contacts, making connection to the switch, and it will be clear that as the truck is drawn out of the cubicle it is entirely disconnected from all live metal, so that any part may safely be examined, cleaned, or repaired if necessary. An interlock on the oil switch prevents the truck being pulled out unless the switch is open, so that the circuit cannot be broken on the isolating contacts. The fact that the truck with all its gear may be wheeled away for cleaning or repair, and that it is possible to get all round it for this purpose, is one of the chief claims for this type of gear. Additional

SWITCH AND CONTROL GEAR AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. ERSKINE, HEAP AND CO., LIMITED, ENGINEERS, SALFORD.

Fig. 1.

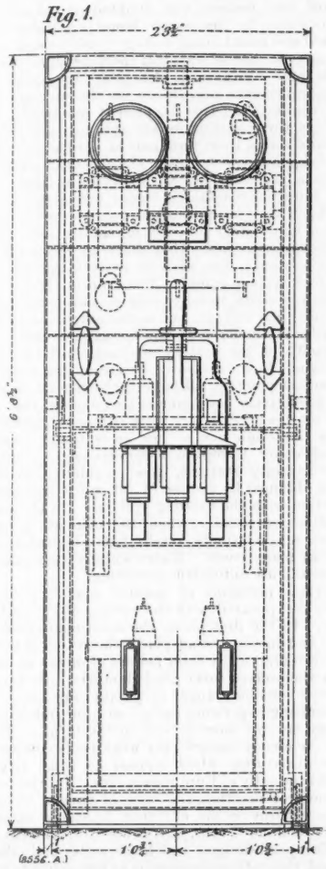


Fig. 2.

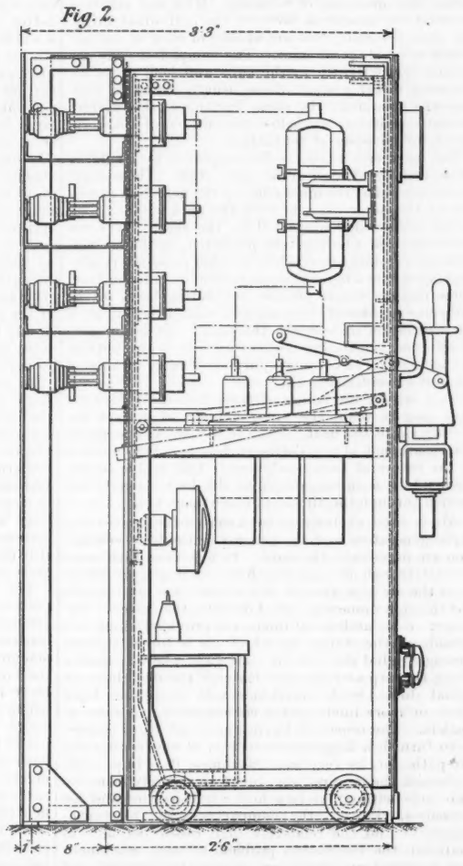
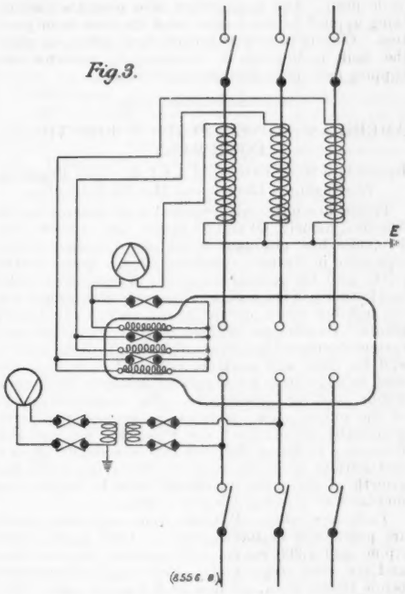


Fig. 3.



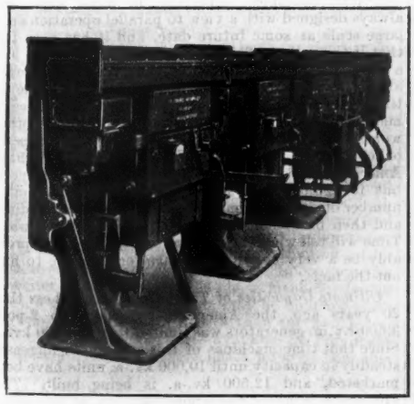


FIG. 4. IRONCLAD SWITCHBOARD.

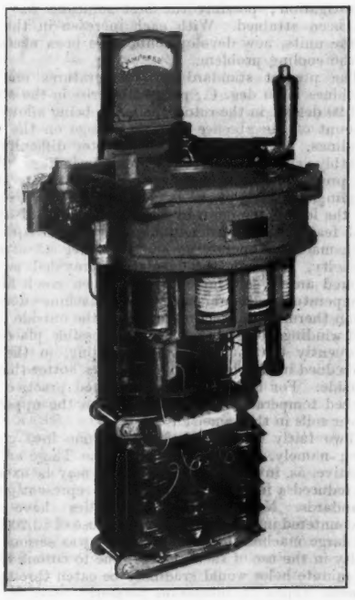


FIG. 5. AUTO-TRANSFORMER STARTER.

advantage lies in the fact that when any truck is removed a spare may at once be wheeled into place, so that but very short interruption of the circuit is necessary. Another advantage of this type of gear is that the isolating switch which is usually introduced between the oil switch and bus-bars in fixed cubicle gear is rendered unnecessary. This reduces both costs and complication. The apertures through which connection is made from the truck to the bus-bars are automatically closed by shutters when the truck is pulled out, so that no live metal is left exposed.

This truck type of gear which can claim so many advantages is not necessarily suited for all conditions, and particularly in cramped sites, which frequently have to be dealt with in works substations, it may well be that sufficient room is not available to allow the trucks to be pulled out and wheeled clear. In such situations the cubicle type of gear, in which the bus-bars are usually carried at the top, may be employed. In this car an isolating switch is generally fitted which is interlocked with the oil circuit-breaker and the door, so that current cannot be broken on the isolating switch and the cubicle door cannot be opened until the gear has been made dead. This type of panel is also made by Messrs. Erskine Heap, and a well worked-out and well-made example of a heavy current panel is to be seen on their stand. A third type of switchgear which has come into use very extensively during recent years is also represented in the firm's exhibit. This is the ironclad type of board, illustrated in Fig. 4, which is particularly suited for use in collieries, rolling mills, shipyards and similar situations. The arrangement is built up in independent panels, each of which carries a bus-bar unit at the top. When the panels are mounted side by side the bus-bar sections are bolted together and form a continuous chamber. The whole of the live and working parts of the gear, except the operating handles for the oil switches, are enclosed in cast-iron cases so that the design is particularly well suited for use in dirty or exposed situations. As will be seen from the figure, brackets are fitted on which the oil circuit-breaker can be run out to the front of the panel for examination. When not in use these brackets can be swung down out of the way. A neat ammeter in a square case, designed to fit the front of the circuit-breaker case, is fitted to each panel. This instrument is of Messrs. Erskine, Heap's own manufacture.

In addition to these three types of switch panels Messrs. Erskine, Heap show a large variety of switches, fuses, starters, instruments, &c. One interesting item takes the form of a rotary synchroniser. This consists of a bank of 12 lamps consisting of six pairs, each pair being connected to the secondary winding of a special six-phase transformer, the primary of which is wound to suit the voltage and periodicity of the circuit on which they may be installed. The lamps are mounted around a disc, and the two forming a pair are mounted at opposite ends of a diameter, so that as one machine gradually overtakes the other the lamps light up in rotation, giving the appearance of a continually revolving band of light. The direction in which the band of light revolves indicates whether the incoming machine is travelling fast or slow, while the correct moment of synchronism is shown by one pair of lamps running at full brilliancy, the ones before and after being equally but only partially lighted.

From among the various types of starters exhibited we illustrated an auto-transformer starter in Fig. 5. The general arrangement of this will be clear from the figure, but there are some valuable features in connection with it which may be mentioned. A stop is fixed as an integral part of the handle lever so that when it is pushed rapidly, as it should be, into the starting position, it is definitely checked there and the operator cannot inadvertently over-run the position. To move forward into the running position he frees the lever by depressing the button at the top of the handle. The hand lever cannot be left in the starting position as, owing to the controlling spring, unless it is held it returns to the off position. When it has reached the running position it may be left there.

The starter is fitted with a loose handle device and cannot be closed against an overload. A valuable isolating plug arrangement is also incorporated in the starter. This is withdrawn when the tank is lowered so that all contacts and connections are automatically made dead. The arrangement also prevents current being applied to the starter until the tank is in position. Current cannot be broken on the plugs, as, when the tank is lowered, it mechanically operates the tripping gear in the first part of its travel.

AMERICAN POWER STATION ELECTRICAL EQUIPMENT.*

By the late B. G. LAMME, M.A.I.E.E., Chief Engineer, Westinghouse Electric and Manufacturing Co.

THERE are only two frequencies in general use in America, namely, 60 and 25 cycles, and of these two, 60 cycles has gradually come into the ascendancy, especially in stations supplying electric power to the public and for general purposes. Twenty-five cycles was formerly in the lead, but has made little progress in the last few years, except in the growth of existing plants. Its principal field has been in connection with systems for converting from alternating to direct current and for steel mill electrifications; that is, it is not used to any extent for supplying power to the general public, and for lighting, &c. The enormous growth of the public utility stations in the past ten years, practically all of which use 60 cycles, has put this frequency so far in the lead that practically all new installations are now made at 60 cycles, while the growth of 25 cycles is almost entirely confined to increases in existing 25-cycle systems.

Turbo-Generators.—With 60 cycles only three speeds are practically available, namely, 3,600 r.p.m., 1,800 r.p.m. and 1,200 r.p.m., corresponding to two, four, and six poles respectively. Practically all machines below 10,000 kv.-a. are now built for two poles, 3,600 r.p.m.; from 10,000 kv.-a. to 45,000 kv.-a. four-pole, 1,800 r.p.m. is used; six-pole machines are only used in extremely large capacities, such as 45,000 kv.-a. or larger. From the purely electrical design standpoint all turbo-generators have now reached, or probably exceeded, the most economical speeds, and the main reason for the high speed lies in the steam turbine.

From the electrical and mechanical standpoints the general designs of the American turbo-generators are quite similar, regardless of their manufacture. The stators or armatures have open slots for the windings, and the armature coils are of the so-called "machine formed" type, being completely formed and insulated before being placed on the core. Usually there are two coil sides per slot, an upper and a lower, and each complete coil has one side in the lower part of one slot, and its other side in the upper part of another slot, usually slightly less than one pole pitch away. Thus all complete coils are duplicates and all are placed symmetrically on the core. The end portions of the coils are of the so-called "barrel" type in all modern machines.

All armature coils in large machines are sunk $\frac{1}{2}$ in. to 1 in. below the stator surface. The principal purpose of this is to reduce eddy current losses resulting from stray field fluxes in the slots through the open tops of these slots. This construction also improves the ventilation of the tooth tips to a certain extent.

In all large machines mica is used to a very considerable extent in the armature insulation, especially in the parts of the coils lying in slots. Mica is also used for the inner layers of the insulators on the end windings, while in some cases the outer layers consist of oiled tape. The armature coils are wedged, in the slot portion, by heavy fibre or wood wedges. The end portions are very heavily braced or supported to resist vibrations and the distorting effects of short circuits. The end windings also have spaces between the adjacent coils for allowing free passage of air through the windings. This part of the winding is directly over the fans on the shaft, and due to the "barrel" end arrangement and the opening between coils, the end windings thus have most excellent ventilation. The "barrel" type arrangement also brings these windings farther away from the stator end plates. The location of the stray fields around these "barrel" type end windings is such that minimum eddy currents are generated in the end plates and surrounding end housings. These eddy currents and the resulting heating can be very severe when the armature end windings lie very close to metal parts.

The rotors of the American built turbo-generators have narrowed down to practically one type; namely, a cylindrical core with numerous radial slots for carrying the field windings. Some cores are built of one-piece steel forgings, while some manufacturers use heavy plates bolted together permanently to form a solid core. The field windings are of copper strip formed into the proper shape and dimensions before being placed in the core and the windings are dropped into the slots one turn at a time, the individual turns being insulated either before dropping into the slot or during the operation of winding. Mica and asbestos are used for insulation between the individual turns. The outer retaining coils are usually of mica or contain a high percentage of mica. The completed coils are pressed down tightly in the slots and held down by retaining metal wedges, these usually being of non-magnetic material. In some instances, the wedges are sunk considerably below the surface of the core, partly for purposes of ventilation.

The rotor end windings are supported by retaining rings, usually of high grade alloy steel. These rings are supported at the inner edge by the field core proper and at the outer edge, beyond the field windings, by radial metal rings supported by the shaft. In some cases the field windings are insulated, in themselves, from the retaining ring, while in other cases the retaining ring carries a layer of insulation on its inner surface. Some manufacturers provide ventilating holes in the end rings in some of the machines, while others depend on ventilation underneath the coils. In some cases small axial ventilating grooves are cut in the bottom of the field coil slots for the purpose of carrying a small amount of ventilating air.

As a whole, the rotors of these generators depend very largely upon the outer cylindrical surface for getting rid of the heat. Four to five watts dissipated per square inch of ventilating surface is not uncommon in the rotors of such machinery. This is due to the tremendous scouring action of the high velocity air carried through the air gap of these machines.

Air is used exclusively in America for ventilating turbo-generators and the general methods of ventilation are practically the same. In machines with cores of relatively short axial length the cooling air is forced in at the air gap, at each end of the rotor, and passes out through numerous radial ducts in the stator. For longer cores, additional inlets are provided along the outside of the stator, by which air is forced inward through radial ducts to the air gap, where it passes along the gap and outward through the neighbouring radial ducts. Such machines will, therefore, have three or more inlets and a corresponding number of outlets. The object of having more inlets, of course, is to furnish a larger cross section of the ventilating air path, for, in very long machines, it is impossible to furnish the required amount of air entirely from the two ends without unduly high air velocities and air pressures. Due to the compactness of the turbo-generator and the relatively high losses per unit of material, the ventilation problem of such machinery has required an enormous amount of thought and investigation; possibly the best solutions have not yet been attained. With each increase in the size of the units, new developments have been necessary in the cooling problem.

The present standard for temperatures on such machines is 80 deg. C., permissible rise in the stator, and 90 deg. C. in the rotor, the latter being allowed on account of the absence of high voltage on the rotor windings, but also due to the greater difficulties of suitably ventilating the rotor core and winding. While the present standard permits 80 degrees on the stator winding, yet most of the larger machines are designed for the lowest temperature practicable without abnormal features of construction and, not infrequently, such machines operate as low as 60 deg. C. at rated capacity, although the insulation provided is considered amply safe for 80 deg. or even much higher. Temperature measurement of such machines does not mean thermometer measurement on the outside of the end windings, or at other easily accessible places, for frequently the interior of the winding, in the part embedded in the slots, is many degrees hotter than the outside. For this reason the accepted practice is to embed temperature detectors between the upper and lower coils in the same slot.

Two fairly high voltages have come into general use; namely, 6,600 and 13,200 volts. These are only relative, as, in individual cases, they may be exceeded or reduced a few per cent., but they represent general standards. No particular difficulties have been encountered in recent years with the use of 13,200 volts on large machines. Formerly there was serious difficulty in the use of such voltage, due to corona effects, as minute holes would gradually be eaten through the fibrous types of insulation formerly used in such machines. However, extensive investigations showed that a liberal use of mica in the stator windings, especially in the parts buried in the core where corona was most pronounced, entirely eliminated troubles of this nature. At the same time, mica furnished a better resisting material for higher temperatures, and thus two results were accomplished by this change.

External short circuits on large turbo-generators are a serious source of danger, due to displacing of end windings, cracking of insulation and resulting injuries and burnouts. Many years ago systems of bracings were devised and also, in some cases, protecting reactances were installed between generators and switchboards. Later, the use of reactances between switchboard and feeders was adopted as affording better protection to the power house apparatus as a whole, and also maintaining voltage conditions at the station buses, in case of external short circuits. The practice is now common in America. In addition, further improvements were made on the bracings of generator windings, so that at present practically all large modern turbo-generators are able to stand dead short circuits across their terminals at normal voltage. The use of separate reactances in the generator circuits themselves is, therefore, not as important as formerly. However, inter-bus reactances, feeder reactances, &c., are considered very important not only to protect the station bus-bar voltage in case of shorts, and thus protect synchronous and other machinery connected to such a system; but also to protect the circuit breakers to a certain extent. The drop in the feeder reactances represents, usually, only a small percentage of the normal line voltage, but as the normal capacity of any feeder is usually very small, compared with the total capacity of the station, a dead short on any feeder does not throw excessive strains on the station.

In American practice, all large turbo-generators are made with relatively poor inherent regulation, that is, the fields are made relatively weak compared with the armatures (although not as low as is found in the practice of many European designers), and, in more moderate capacity stations, good regulation in the systems is obtained by the use of automatic regulators in connection with the exciting systems. In the very large stations, especially when the changes in load increments are relatively small, hand regulation is still used in many cases. Water-wheel driven plants quite generally use automatic regulation.

The former problems of parallel operation have practically disappeared with the coming of the turbo-generator. In the first place, the rotational speed is constant, and in the second place the rotors of such machines are practically solid masses of metal, so that the cores themselves form good dampers. However, there is one possible danger in parallel operation, of which operating experience has given some indication, which may become more serious in the future. This lies in the tendency toward very weak fields compared with the armatures, which appear in some recent machines, especially of European makes. In American turbo-generator practice, the ratio of normal no-load field ampere turns to the effective armature ampere turns very seldom, if ever, falls below 0·8, whereas, in certain European designs, which the writer and others have noted, this ratio sometimes is as low as 0·4 to 0·5. American machines, especially in large sizes, are always designed with a view to parallel operation on a large scale at some future date, and it has been felt that if the ratio of field to armature is made too low a condition will eventually be reached where under abnormal conditions, which may occur from time to time, the armatures of such machines magnetically may take control of the fields, so to speak. In other words, such machines may fail to parallel properly or may "hunt" under abnormal conditions. Perhaps American practice has been unduly safe in this respect, but it would be a very serious matter to put out a number of very large machines with low ratio windings and then find such machines were inherently unsafe. Time will tell what the real limits are, and it will probably be a very costly experience for someone to find out the facts.

Ultimate Capacities of Turbo-Generators.—Less than 20 years ago, the American practice with 2-pole, 3,600-r.p.m. generators was limited to about 600 kv.-a. Since that time machines of this speed have increased steadily in capacity until 10,000 kv.-a. units have been marketed, and 12,500 kv.-a. is being built. This appears to be about the largest capacity, at this speed, which can be built with self-cooling by ventilating fans on the shaft. However, on paper, such machines appear to be possible up to 15,000 or 20,000 kv.-a., if cooled by separately-driven fans. Compared with European practice, with 2-pole, 3,000-r.p.m., 20,000 to 30,000 kv.-a. machines, which have been designed, the American limits look, at first glance, to be rather low; but it must be kept in mind that there is a large inherent difference between 3,000 and 3,600 r.p.m., the possible ultimate capacities varying approximately as the cube of the diameter of rotors and directly as the r.p.m.

A 27-in. diameter of rotor at 3,600 r.p.m. corresponds to a 33-in. diameter at 3,000 r.p.m. This difference appears small, but it is of fundamental importance in the problem of maximum output of the machine. It is the diameter below the rotor slots that is important, as far as mechanical limits are concerned when the maximum output is under consideration. At 3,600 r.p.m., with a given length of core, this diameter

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must be as large as at 3,000 r.p.m. with somewhat longer core; and thus the depth of rotor slots must be very materially reduced, with a corresponding reduction in the field windings and in the capacity of the machine. A further lengthening of the rotor core, to increase the capacity, will mean still shallower slots and further reduction in field copper, so that there is a point beyond which there is no gain or there is actually a loss in capacity.

When it comes to four-pole, 1,800 revolution machines the problem has narrowed down to one of ultimate diameter and length of rotor core. The limit of stresses in the cores has not yet been reached, but the retaining end rings represent a real limitation, and unless materially stronger constructions are devised to withstand higher speeds than at present, the growth of such machines will have to be almost entirely in length. With the present dimensions and lengths, capacities of about 45,000 kv.-a. are being built; and, considering all the future possibilities, one might predict that 65,000 kv.-a. may be obtained some time in the future.

On six-pole, 60-cycle machines, it is difficult to predict the upper limit. At present 65,000 kv.-a. machines are being installed, and if the present constructions are carried to the extreme, ultimately 90,000 to 100,000 kv.-a. may possibly be obtained, if such sizes are wanted. All these, of course, are crude estimates, and, considered purely in the light of past growths, would not appear to be very extreme. But it must be borne in mind that we are approaching closer and closer to the ultimate limits of our materials.

In 25-cycle polyphase machines, 1,500 r.p.m. units have been built for 40,000 kv.-a., and presumably this may be carried to 60,000 kv.-a. when there is serious need for such machines.

In single-phase generators, it is difficult to make any reliable prediction. Single-phase, 1,500-r.p.m., 25-cycle machines have been built, in America, up to capacities of 15,000 kv.-a., and there is reason to believe that such machines can be built for much larger capacities, such as 25,000 kv.-a., or more. One of the serious limitations in the design of such machines, as compared with 25-cycle polyphase generators, has been the relatively low power factors at which heretofore they have had to operate; namely, 80 per cent. A real difficulty in the design lies in obtaining sufficient ampere turns on the two-pole rotors to give the required output at the low power factor. Usually, it has been supposed that the most serious limitation has been in the construction of suitable dampers on the rotors for suppressing the negatively rotating component of the armature flux. While this also has been quite a problem, yet it is only one of the limitations. Practically, all polyphase generators for 25 cycles in American practice have been built for relatively high-power factors, as the load of such machines has been largely in the nature of synchronous converters or synchronous motor sets. Thus, polyphase, 25-cycle machines have been built for extremely good conditions, whereas the single-phase machines have been built for much more difficult conditions.

Up to the present, 60-cycle, single-phase generators have had little or no field, in America, but there may be possible future demand for such machines. It has been claimed by some designers that 60-cycle, single-phase generators would be almost impossible in large sizes, due to the difficulties in damper construction. However, as four-pole and six-pole constructions lend themselves much better than two-pole machines, both to the use of relatively larger field ampere turns and to the application of dampers, any disadvantages, due to higher frequency, may be more than off-set by the more advantageous constructions. In consequence the writer believes that single-phase machines for 60 cycles, with four and six poles, may be built for possibly relatively higher capacities than for two poles, at 25 cycles. The only tests available on polyphase machines, operated on single phase, seem to bear this out.

A.C. Water-Wheel Generators.—Water-wheel generators of American make are, with few exceptions, of the vertical shaft type, with internal rotating fields and external stationary armature. The application of vertical shaft generators has been greatly accelerated by the development of a satisfactory thrust bearing ten or twelve years ago. Up to that time, thrust bearings were of various types, such as ball and roller bearings, plain collar bearings and oil pressure bearings, none of which appeared to be entirely satisfactory for supporting heavy weights. The thrust bearing, which first made the vertical generator commercially successful in American practice, was the Kingsbury bearing, in which the stationary bearing surface is divided into segments, usually six, and in which the segments are so supported as to slightly tilt and form wedge-shape oil films. This bearing is very similar to the Michell bearing, developed in England. Since the development of the Kingsbury bearing, other types having other methods of adjustment have been developed and are in successful use.

The automatic operation of hydro-electric generators in stations without attendants is rapidly increasing. Machines as large as 5,000 kv.-a. are now operated in this way. A 10,000 kv.-a. hydro-electric generator is now under construction to be installed in a station without attendants and operated by a supervisory control system over wires coming from another station at a distance of several miles.

Synchronous Condensers.—These are called for in large capacity units in connection with large generating systems for regulating voltages and correcting transmission line conditions; and while they are not real "producers" of power, yet they are very necessary as regulators, especially in connection with transmission systems at 60 cycles. The growth in the use of such machines has been very rapid in the last few years, and, with the coming of the super-power system, the field for them will be still larger.

The speeds for such units are chosen for the lowest cost, and are the highest for which the present dove-tailed salient pole construction can be used. Ordinarily, synchronous condensers are designed for moderate overspeeds, namely, 25 to 50 per cent., but occasionally the conditions are such that the condenser should be capable of operating safely at the water-wheel overspeeds, that is, as high as 80 per cent. The usual speeds for 60-cycle condensers are as follows:—

5,000 to 10,000 kv.-a.	720 r.p.m.
15,000 to 30,000 kv.-a.	600 r.p.m.

It should be understood that these are not the highest speeds for which synchronous condensers can be built, but represent the lowest cost under present conditions of construction.

These synchronous condensers are ordinarily designed for full kv.-a. output at the over-excited condition, and have a steady short-circuit ratio of 0·6 to 0·7, that is, with steady short-circuit with normal voltage no-load field current, they would give 0·6 to 0·7 of the rated armature current. Such condensers would carry approximately 50 per cent. of their rated kv.-a. lagging. Condensers for application on transmission lines frequently operate under-excited (when the line is lightly loaded) to prevent an objectionable increase in received voltage; and in order to secure stability at low excitation, the relative strength of the field winding must be increased and the normal short circuit ratio may be as high as 1·3. While salient pole condensers will operate with low values of reversed excitation—up to 50 per cent. of no-load normal voltage excitation in some cases—it is not considered good practice, as under this condition of reversed excitation the condenser may drop out of step with minor line troubles.

Large condensers are usually started as squirrel cage induction motors by the application of reduced voltage. The desired starting voltage may be obtained either from taps on the transformers, when transformers are used, or from a separate auto-transformer. Condensers of 5,000 kv.-a. and larger, usually have an auxiliary motor-driven oil pump of sufficiently high pressure (800 to 1,000 lb. per square inch) actually to lift the rotor journals from contact with the bearings. This is done before the starting voltage is applied and permits a very considerable reduction in starting voltage and kv.-a. Usually condensers provided with such oil-pressure systems are started by the application of 25 to 30 per cent. of rated kv.-a. A particular 20,000 kv.-a. condenser started on test at 19 per cent. voltage, taking 2,800 kv.-a. from the line and required three minutes to reach synchronism.

In the design of synchronous condensers the attainment of low losses has been considered very important. In a commercial line of condensers from 5,000 kv.-a. to 30,000 kv.-a., the guaranteed losses at zero power factor over-excited, vary from 3 per cent. to 2 per cent. of the kv.-a. rating. In a particular installation of two 20,000 kv.-a. 11,000 volt, 60-cycle, 600 r.p.m. condensers, the full load zero power factor losses were 400 kw. and 391 kw., an average of less than 2 per cent. It may be of interest to note the fact that approximately two million kv.-a. in synchronous condensers of all sizes have been contracted for by American firms. Practically all of these machines have been ordered during the past 12 years.

Frequency Changer Sets.—As stated before, 60 cycles has become the standard frequency in the United States, and a very large proportion of new generating equipment is for 60 cycles. But there is still a large 25-cycle load, mainly in synchronous converters, supplying direct-current distributing systems in the larger cities, in steel mills which some years ago adopted 25 cycles as their standard, and in the Niagara district. There is also in Southern California a large 50-cycle area. This situation has brought into use large equipments to interchange power between systems of different frequencies. The Brooklyn Edison Company and the United Electric Light and Power Company have each installed a 35,000 kv.-a. frequency changer set to supply 25-cycle synchronous converter loads from 60-cycle generators. Twenty-five cycle power can be supplied more economically in this way than from the older 25-cycle generating stations installed less than 10 years ago. The combined efficiency of one of these 35,000 kv.-a. sets by test after installation is over 95 per cent., an average of 98 per cent. for each machine of the test. The Southern California Edison Company has had in operation more than two years a 15,000 kv.-a. set, tying together their 50-cycle system and the 60-cycle system of the San Joaquin Power Company. Both machines of this set are wound for 18,000 volts, and the speed of the set is 600 r.p.m. This is the highest operating voltage for which machines have been wound, and involves a one-minute test voltage of 40,000 volts on the completed machine, and 50,000 volts on the individual armature coils. These are the highest tests that are recommended for windings in air.

Practically all of the larger frequency changer sets installed in the United States are of the synchronous-synchronous type. There are a few induction-synchronous sets installed for special reasons. It has become quite common to provide motor-operated frame-shifting devices in the synchronous-synchronous sets so that sets can be connected to and disconnected from the lines more conveniently, and to provide means for varying the load on the set.

Frequency changer sets are usually started (from one or either system) as squirrel cage induction motors. Squirrel cage windings of special design are provided for the purpose. A high-pressure oil system is used in starting large sets, as in the case of large synchronous condensers. The 35,000 kv.-a. set operated by the Brooklyn Edison Company is started by isolating a turbine generator and starting the generator and set synchronously. This results in very smooth and easy starting conditions.

An interesting type of frequency changer set has recently been furnished to the United Electric Light and Power Company of New York City by the General Electric Company. This consists primarily of a 35,000 kw. induction motor with approximately 60 cycles on its primary, and operated at such a speed as to give 25 cycles on its secondary (that is, at 42 per cent. slip), the rotor being connected to a synchronous motor.

Power Station Auxiliaries.—There is a general tendency toward the electric driving of power station auxiliaries. Many of the stations now being installed use alternating current motors throughout, with squirrel cage induction motors for constant speed, and for variable speed, using either multi-speed squirrel cage induction motors or polyphase commutator motors. Some operating engineers, however, favour direct current for the variable speed auxiliaries, and install both alternating and direct-current supply. There is a recent tendency toward supplying the auxiliaries from a generator direct, coupled to the main steam turbine shaft. Such generators have usually been of the alternating current type, of from 5 per cent. to 7 per cent. of the capacity of the main turbine. It is felt that with this general arrangement, the driving power for the auxiliaries is as reliable as it is possible to make it. For starting in emergencies, a separate supply, either from the main bus, from an outside station, or from an auxiliary station, is usually available.

Transformers.—Transformers should be included in power-house equipment, for not infrequently they form part of the main generating plant. Auto-transformers with a 2 to 1 ratio have been used for stepping up from 11,000 volts or 13,200 volts to double these voltages; or in many cases two-coil transformers have been used for stepping up to much higher voltages for transmission systems to these stations. Large transformers are built both of the self-cooled and of the water-cooled types.

The water-cooled type is used almost exclusively in power-house work, for such transformers can be built more cheaply than the self-cooled type, and water is almost always available. Either type can be built for large capacities, the self-cooled type having been built up to 18,000 kv.-a. per unit, and still larger sizes doubtless can be built. The water-cooled type can be built in almost any capacity.

The American type transformers are of two general constructions, namely, three single-phase units and straight three-phase units. In large transformers, the use of the single-phase units is much more common, principally on account of flexibility in application. For a given capacity, the three-phase unit may be slightly cheaper, considered by itself, but when spares and the problems of repairs, &c., are taken into account the single-unit construction often works out with less cost.

Formerly the tendency in large transformers was toward relatively low reactance. However, due to dangers from short circuits, &c., this general tendency has changed toward fairly high reactance, both as a matter of safety against shorts and also for general operating reasons, such as better paralleling, &c.

Reactors.—The use of reactors has come in gradually,

and they have become such an important part of the operating outfit that it may be said that it would be impossible to operate our largest modern power stations in a satisfactory manner without current-limiting reactors in some form or other. Maintenance of service, which is of first importance in all such stations, is now, to a very great extent, dependent upon current-limiting reactors in some form or other.

Recent Switchboard Practice for Power Houses.—The realisation of the importance of safety to life and property is reflected by the enclosing of all live parts either by masonry or grounded metal barriers, as truck type switching equipments, dead front switchboards with inclosed rears.

Complete factory built and assembled switching equipments, particularly for small power plants and auxiliary circuits of large plants, centralise in one place the responsibility for the individual apparatus as well as the assembly of all into a properly co-ordinated and permanently satisfactory whole.

Segregated-phase breaker and bus arrangement is a thoroughly modern method of meeting some of the hazards attendant upon the concentration of heavy powers in that the only short circuits that can occur are to ground where the magnitude of short circuit is limited by the ground resistance, thus avoiding any serious electrical or mechanical disturbance.

The condensing of the control equipment for manipulating power house apparatus into very small area and space is strongly emphasised. By this many more operations and much more apparatus may be placed under the complete control of a single operator. This makes for improved service and efficiency. Prompt and correct action to meet the various emergencies arising on large systems is so imperative that the old method of telephone control on the part of the load dispatcher is no longer adequate. Supervisory control of the various operative functions is coming into use on large systems to meet the requirements of the present day.

Automatic switching equipments for generating stations permit their safe operation and proper functioning without attendants. This has made practicable and profitable operation of relatively small water power which otherwise could not be utilised and promises considerable application in this and other fields.

The great concentrations of power now common in America are made possible only by the development of the oil circuit-breakers, which, so far, are the only commercial apparatus suitable for handling heavy short circuits at high voltage. Oil breakers, rated to rupture 1,500,000 kv.-a. in the arc, are now in successful use on generator circuits and high voltage transmission circuits.

For very heavy power house service, that is, where the ultimate output of a station is 200,000 kv.-a. or above, isolation of phases in the switch house is being used in nearly all new stations. This isolation is of two types. With horizontal isolation, each phase of an oil breaker, for instance, is separated from the other two phases by compartment walls on the same floor. With vertical isolation, each phase is separated by being placed on a separate floor. Either type, when properly designed, practically insures against the possibility of a phase to phase short anywhere from the generator terminals to the outgoing cable pot ahead.

So far, little consideration has been given to isolation of phases in substations, regardless of the amount of power handled, and high power circuit-breakers with all three poles mounted on a single frame are in general use in such substations.

There has been in the last few years a marked swing toward the use of dead tank, gravity break, oil circuit-breakers with both the main and auxiliary contacts immersed in oil at all times. The fundamentals of design have remained extremely simple, there being no tendency in this country to go to the multiplicity of breaks in series that is common in Europe. With one or two unimportant exceptions, all breakers are of the double break type covering all voltage classes up to 200,000 volts.

Automatic Stations and Substations.—The use of automatic hydro-electric generator stations has already been mentioned. The operation of the apparatus in the substations without attendants is rapidly increasing in the field of electricity supply, including substations and the supply of direct current to street railways, mining and factory installations, and direct current lighting systems, also transformer substations for the general distribution of alternating current at 2,300, 4,000 and 6,000 volts, and also voltage regulators and street lighting. In such stations the entire operation of the station may be automatic, including protection of the transformers and running machines, automatic reclosing of outgoing circuit-breakers, shutdown and starting of the machines when necessary on account of load variations, and starting up of street lighting circuits, &c. By the introduction of supervisory control systems the starting and stopping of machines in circuit and closing of oil circuit-breakers, &c., may be controlled from a distant station, confining the automatic equipment generally to the protection of the apparatus in the automatic station.

THE DIESEL ENGINE.*

By DR. ADOLPH NÄGEL.

The Diesel engine has been developed along four principal lines in Germany since the war: first, the main type of the engine has been freed from certain handicaps caused by too close an adherence to the original model; second, the two-stroke cycle is being used for large engines; third, there is an increasing tendency to inject and atomise the fuel without the aid of compressed air; and fourth, much progress has been made in the use of fuel of low ignitability.

It has to be admitted that the Diesel engine without compressor became recognised in Germany at a comparatively late date, and that the leading firms, with very few exceptions, did not set great store by the airless injection of fuel. It was only when economic conditions made it imperative to lower the cost of construction that the interest in the simplified Diesel engine made itself felt. To-day it can be stated that the economic pressure which makes solid injection necessary is felt by the German Diesel engineers as a far-reaching impetus for renewed activity.

Before the war many attempts had been made to separate part of the combustion air which had been compressed in the combustion chamber of the working cylinder, and to compress it still further in order to use it for atomising. All these attempts failed because the different parts used in the new constructions afforded no safety in working. So long as this method is not revived in one form or another we have to distinguish between two types of Diesel engines only: the antechamber engine and the jet-spray engine.

With the former kind, the antechamber engine, the atomising of the fuel is produced by an additional pressure of air which originates by means of an auxiliary explosion within the antechamber. Between the antechamber and the working cylinder a nozzle or a system of nozzles is placed in order to convert the pressure of the antechamber gases into velocity and to utilise it for atomising. The nozzle is the characteristic feature of the Diesel engines in contradistinction to the ignition head engines, which work with low compression and whose antechamber is not separated from the combustion chamber by a nozzle.

Whereas with the ignition head engine the spontaneous ignition is caused solely by the high temperature of those parts of the surface of the ignition head which are hit by the jet of fluid, the antechamber Diesel engine, in order to bring about spontaneous ignition, utilises also the increase of the temperature of the combustion air as originated by compression in addition to the temperature of the inner surface of the antechamber.

With the jet-spraying engine one or several very thin jets of fuel enter the combustion chamber direct under the high pressure of several hundred atmospheres. The atomising of the fluid is caused by the dissipation of these jets, which is brought about through the influence of the friction of the jet on the compressed charge of air. As soon as this principle is realised it becomes evident that we must allow the jet to travel within the combustion chamber a distance sufficient for its dissipation. If it should strike the wall too soon the dissipation would not be complete and the quality of combustion would be appreciably lowered. This is the reason why a complete success was scored when several years before the war horizontal Diesel engines were built with solid injection.

The peculiar construction of the combustion chamber of this horizontal engine afforded sufficient travelling space for the jet to dissipate before it could hit the surface of the piston as a solid jet. Conditions differed, however, when an attempt was made to adopt this mode of dissipating the jet for the usual type of vertical Diesel engines, where the jet of the fluid, entering axially and travelling only a few centimetres, hit the surface of the piston directly. The failure resulting from this impeded for a long time the development of the solid injection engine of the vertical type, until it was recognised that it was the short travel of the solid jet which prevented its even dissipation, a shortcoming which has been overcome by a hemispherical depression of the piston surface.

Fig. 1 shows the needle-tube arrangement adopted in one design. This opens automatically under the pressure of the fuel. Under it the head of the piston on the upper dead centre is to be seen. All tests with several engines of this type resulted in records of efficiency. The latest tests were made by Professor W. Maier, Stuttgart, who obtained the values registered in Fig. 2. If these are reduced to a net calorific power of 10,000 calories per 1 kg., and if a normal load of 360 e.h.p. is assumed, we obtain the following values of fuel consumption per e.h.p. per hour:—

¼	load	224 g.,
½	,, ...	177 g.,
¾	,, ...	168 g.,
1/1	,, ...	167 g.,

and

5/4 load .... 177 g.

This exceedingly small consumption of fuel is remarkable. The minimum of 166 g. was attained with a load of 320 e.h.p., which corresponds to a thermal efficiency of 38·3 per cent. It must also be emphasised that the fuel consumption is in a large measure independent of the load; within the wide range from half-load to 25 per cent. overload the minimum fuel consumption is exceeded only by 6·6 per cent. A careful analysis of the underlying causes has shown that only about 50 per cent. of this favourable result is due to the absence of the compressor work. A large part of it is to be attributed to the hemispherical, practically uniform combustion chamber, whose cooling surface is comparatively small, as well as to the high mechanical efficiency, amounting to 85 per cent. The engine stands an overload of nearly 50 per cent. Professor Maier was able to make a satisfactory test with a fuel consumption of 188 g. at a mean effective piston pressure of 7·83 atmospheres. As the normal load of 360 e.h.p. corresponds to a mean effective pressure of 5·5 atmospheres, the overload is

$$\frac{7{\cdot}83 - 5{\cdot}5}{5{\cdot}5} = 42 \text{ per cent.}$$

Experience seems to point out that the solid injection engine of this type very favourably influences the wear of the piston, whose upper surface is very effectively cooled by the contact with the spray of the fuel. The heat thus drawn from the piston surface is used for vaporisation and for cracking the small fuel drops. It is believed that for this reason a separate cooling of the piston can be dispensed with for larger diameters than is the case when the spraying is effected by compressed air.

Very similar devices have been successfully used by other firms. The fuel pump in one type of four-stroke cycle engine is worked by a cam projecting from the crankshaft. In case of a two cylinder engine the fuel is admitted alternately into either cylinder by means of a distributor which is connected with the gear-shaft; with single-cylinder engines on every second stroke of the pump the fuel is by-passed to the fuel tank. Fig. 3 shows the injection nozzle. The needle, which opens automatically under the pressure of the fuel, is provided with a lift-stop in shape of an inverted mushroom valve. If the needle is lifted this valve presses tightly against the lower surface of the upper bush of the needle guide. In this way the packing of the needle can be dispensed with, and a weak spring will prove sufficient for loading the needle. The nozzle proper has five pairs of holes which are equally distributed on the circumference. Each pair consists of a horizontal and an oblique bore, each 0·3 mm. in diameter. Both bores of each pair meet at the point of discharge; thus the two jets combine and the atomising of the jets occurs. This engine has yielded a fuel consumption as low as 163 g. per effective horse-power-hour.

A large number of engineering works are also interested in the antechamber Diesel engine. This type does not yield the exceedingly low fuel consumption which is the feature of the most economical types of the jet-spray engines. But it is also very advantageous as it requires less precision in manufacture, dispensing as it does with the two most sensitive parts of most of the jet-spraying engines, viz., the injection nozzle and the needle mechanism. According to our latest experience it is a matter of doubt whether preference is to be given to the antechamber engine or to the jet-spray engine if we sum up the advantages of either system, such as low prime cost, safety in working, easy operation by the factory hands, and, last but not least, low fuel consumption. I discussed the chief types of antechamber engines which are now being built in Germany in a lecture delivered to the Verein Deutscher Ingenieure in Berlin last year. The feature of the Steinbecker antechamber engine is the introduction of the fuel into a nozzle zone which is placed between the antechamber and the working cylinder. Through the current of air which flows, during compression, from the working cylinder to the antechamber, the small particles of fuel which are first introduced into this zone are carried into the antechamber, whose walls, brought to blood-red heat, cause the spontaneous ignition of this very small amount of fuel. In consequence of the combustion pressure in the antechamber, which suddenly rises to 80 atmospheres, the direction of the current within the nozzle is at once reversed, and this new current causes the bulk of the fluid which now follows to be

* Paper, abridged, contributed to Section E of the World Power Conference on July 8, 1924.

injected into the cylinder and atomised with the aid of the gas pressure in the antechamber.

Among the antechamber engines, in which the entire fluid passes through the antechamber, one type has been particularly successful. As seen in Fig. 4, the antechamber is cast into the cylinder cover between the inlet valve and the exhaust valve and completely

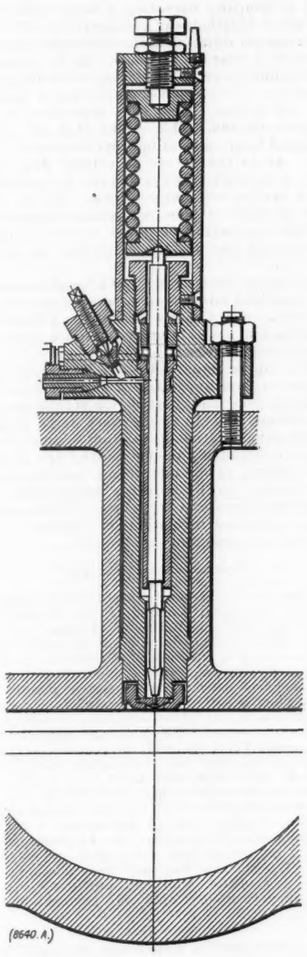


FIG. 1.—Needle Tube Injection for Vertical Diesel Engine.

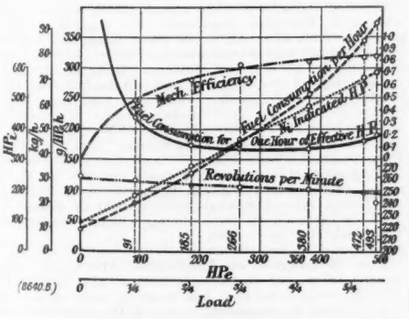


FIG. 2.—Results of Tests made by Professor W. Maier, Stuttgart.

D = 360 mm. s = 580 mm. n = 250 r.p.m.

covered by the cooling water with the exception of the bottom. The fuel nozzle, which is provided with an automatic needle, runs from above axially into the antechamber. The centre part of the bottom of the antechamber tapers into a jet-spraying nozzle which is arranged axially and opens into the combustion chamber of the working cylinder. The jet-spraying nozzle is part of a separate fixture which expands upwards into a funnel, thus forming the centre part of the antechamber bottom. All around this fixture grooves are machined, in order to prevent the transmission of its heat to the cooled surface of the cylinder cover. Thus it reaches so high a temperature that the more or less solid jet of fluid, when it strikes against the hot surface of the funnel is ready for complete combustion. When the cold engine is put

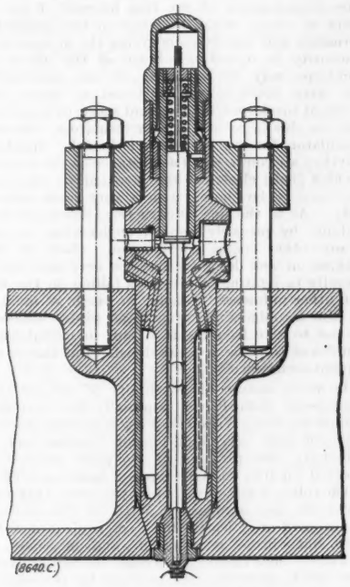


FIG. 3.—Needle Tube and Spraying Nozzle for Four-Cycle Engine.

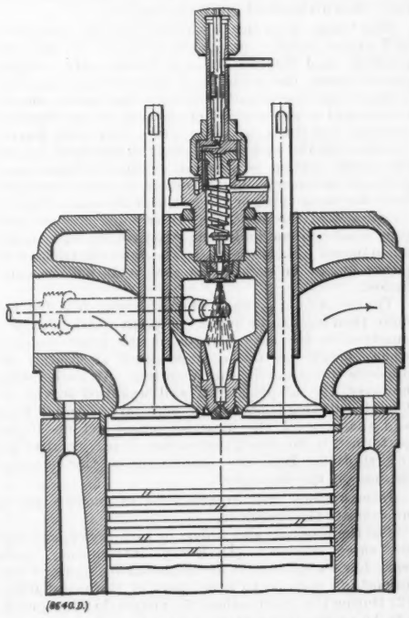


FIG. 4.—Antechamber Diesel Engine.

in motion, the ignition of the fuel is first effected by means of a glowing fuse of nitrated paper which projects into the antechamber.

All systems of solid injection engines have hitherto been restricted in Germany to types working with small cylinders. The excellent results obtained with atomising liquid fuel by means of a compressor, which resulted in a maximum of reliability, were responsible for the retention of the compressor in large engines such as are used particularly for large-sized motorships. The preference seemed all the more justified by the fact that the sensitiveness of the air compressor decreases with increasing size, and that the compressor adds less to the prime cost of the entire plant in proportion as the size of the engine increases.

All these reasons explain why the German Diesel engines for marine purposes, with the exception of smaller types, continue to this very day to inject the fuel by means of an air compressor. All these different systems of motors for the propulsion of ships are in lively competition with each other, and their friendly contest is far from being definitely settled. On the one side we have the heavy slow-speed Diesel engines with direct reversing. With them there is an increasing tendency to abandon the original four-stroke type almost completely. The chief variations are the revolutionary adoption of radically new driving gear arrangements and, wherever maximum output is required, the introduction of the two-stroke cycle with single or double-acting piston. On the other hand, owing to the vast experience, which has been gathered with high-speed marine Diesel engines, there is also an endeavour to render this latter type more efficient by adding a speed-reducing gear.

The reversible slow-speed type has been considerably developed in Germany in recent years. Among new driving gear devices we have first to mention the Benz engine. This replaces the cross-head guide by a strong rocking arm, which is also the point of application for the pistons of two four-stroke cylinders and which transmits the work of these two pistons to a common connecting rod. The four stroke phases of these two combined pistons differ by 360 degrees.

The Michel motor has assumed a shape which differs completely from the usual type of the Diesel engine. Its latest model is a two-stroke cylinder with three pistons in radial arrangement.

In addition to the improvements which the Diesel engine for marine purposes has been subject to with regard to the driving gear, much progress has been made respecting the utilisation of the cylinder. This progress chiefly consists in the development of new two-stroke systems. The principal endeavour is to obtain the highest possible cylinder output. This is the reason why the double-acting working cylinder has of late again been successfully resorted to. The modern tendency no doubt is to pass from valve scavenging to port scavenging which is controlled by the working piston. The special advantage of this method consists in the simplification of both cylinder head and cylinder cover, since not only the exhaust valve but also the scavenging valves can thus be dispensed with. The first successful experiments along these lines were made in 1914 when a single-acting trial engine was tested of the well-known two-stroke type. In the single working cylinder 1,992 effective horse-power was obtained at 150 r.p.m., the diameter of the piston being 1,000 mm. and the stroke 1,100 mm.

Of special interest are the excellent results obtained with a new double-acting two-stroke trial engine. This engine has been thoroughly tested with a double-acting, two-stroke cylinder of 800 mm. diameter and a stroke of 1,050 mm. The ratio of the stroke is comparatively small (1 : 3); this is due to certain parts of the engine which were on hand and were made use of for the trial engine. With ordinary engines a larger ratio will be chosen for the stroke. Particular attention has been paid to an advantageous circulation of the cooling water within the jacket of the cylinder liner. The upper cylinder cover is provided with a fixture in which are placed the fuel valve, the exhaust valve, and the safety valve. The lower cylinder cover, which is provided with a cooled wrought-iron protection plate, contains four fuel valves and one safety valve.

This engine was started on December 18, 1923. From the outset it has been working very satisfactorily, so that the construction of six-cylinder engines with 10,000 e.h.p. and 94 r.p.m. is planned.

Taking into account the work of the scavenging pump, the trial engine yielded 984 e.h.p. at 88·7 r.p.m. The fuel consumption, reduced to a net calorific power of 10,000 calories per kilogram, was 187 g. per one hour of 1 e.h.p. The mean effective piston pressure was as high as 5 atmospheres. With a half-load, i.e., 515 e.h.p. at 89 r.p.m., the fuel consumption only went up to 200 g. Calculated per one hour of 1 i.h.p., the fuel consumption for a half-load up to a full load remained constant at 150 g.

Quite recently a port scavenging engine has been adopted. The arrangement of this engine resembles the previous type; it avoids, however, the sudden change in the direction of the current within the cylinder before it enters the exhaust ports. For this purpose the exhaust ports are not placed above the scavenging ports, but are distributed sidewise in two groups along the cylinder wall opposite the scavenging ports. Thus the scavenging current flows through the cylinder in a continuous circle which splits up into two currents in order to leave the cylinder at the exhaust ports. For smaller marine Diesel engines, up to about 400 e.h.p., one firm uses a sun and planet coupling. This coupling offers the same advantages for smaller marine engines as the Vulcan gear does for ship motors of a large size.

A final word may be said about the similar task of

utilising the Diesel engine for locomotive and freight motor-car service. Many German engineering works are interested in these two problems. For locomotive service two firms have been using the Lentz coupling. A 1,200-h.p. Diesel locomotive for goods trains has been constructed by one firm.

THE CONTINUITY AND REGULARITY OF OPERATION OF LARGE ELECTRIC SYSTEMS.*

By DR. GUIDO SEMENZA.

IT has been pointed out that the extension of an electric distributing network is favourable to economy but detrimental to service. I recall in connection with this, the old Edison system in Milan, which was running for fourteen years from 1882 without a single interruption of current and with the variations of voltage kept within limits of 2 or 3 per cent. When a single steam power house was feeding its own network, these results were possible. They are still possible in networks in which distribution is made by direct-current with a sufficient amount of storage batteries. But when the energy comes from hydraulic sources and has to be transmitted over long overhead lines, and distributed without auxiliary storage batteries (and I think this is the case in at least 90 per cent. of the plants on our continent) interruptions and irregularities in the service are quite frequent. It is interesting to investigate if this has to be considered as a normal condition or if it is, on the contrary, a degeneration to be corrected.

The war has had a part of responsibility in this state of affairs, as in the course of events it was necessary, above all, to produce and deliver as many kw.-hours as was possible, and the continuity and regularity of service had no importance whatever. Once the war was over, the majority of the producers and distributors of energy were not in a position to renew such parts of their plants as had become obsolete, and the consumers very naturally became gradually accustomed to bad service.

It is said that improvement of relationship is possible between two parties, only when it works in favour of both. The object of this paper is to show that improvement of service is an advantage both for the consumer and the producer, but perhaps more for the producer; in fact, for the customer bad service may be only a nuisance, for the producer it nearly always represents a loss of money.

Bad service may depend on: (*a*) short-circuits in power house or substation bus-bars and connections; (*b*) break-down of electric machinery (alternators, dynamos, transformers) and switchboard apparatus; (*c*) insulators puncturing or conductor breakages or cable break-down; (*d*) lighting disturbance or failures of protective devices; (*e*) insufficiency of regulating facilities and protecting devices, in particular when more than one power house is working on the same network.

A first broad classification of these different causes can be made: those that can easily be avoided (even if the remedy is very costly) and those that are to be considered unavoidable or nearly so.

In the first class I would mention short-circuits in bus-bars, insufficiency of conductor sections and insufficiency of regulation facilities on large networks. Short-circuits in bus-bars and on conductors of power houses and substations can be avoided by good construction. We have nowadays enclosed systems that give every security against such danger, and even without going to the high cost of such systems, the lay-out of inside conductors can be done in such a way as to make such evils practically impossible. Insufficiency of conductor section is a question of cost; insufficiency of regulating facilities is not so simple to rectify. The problem of voltage regulation in a large network, which a number of power houses are feeding, and which is perhaps formed by the interconnection of several separated networks, is rather a difficult one, as it involves proper distribution of active and reactive power. These networks have at any rate proved to be very sensitive to voltage regulation; any abnormal occurrence at one point is apt to affect the whole system. The mere tripping of protective apparatus may be sufficient to alter all of a predisposed plan of regulation. Therefore in such systems, the necessity of feeder regulators and synchronous condensers becomes more and more frequent.

Now, if we come to abnormal occurrences due to break-down of machinery and apparatus, although accidents of this kind cannot be absolutely avoided, they can be reduced very much by a proper choice of machinery. Poor machinery is the cause of more troubles than is generally believed. Care must be taken not to put too much of the responsibility for the production of poor machinery on the manufacturer's shoulders, as the quality of the production must very often follow the tendencies of the buyers. I submit that too often the electric companies give a place of excessive importance to first cost of machinery and too small importance to the cost of operation. This tendency, especially in some of the Continental countries, has lowered the whole standard of machines, and a better consideration of the true interest of the producers of energy ought to result in the demand for alternators and transformers giving the highest degree of security in operation. Some of the above considerations may be extended to line construction. Very often break-downs attributed to birds, stones thrown at insulators, lighting and straw carried by the wind, are due in reality to poor insulators. Economy in insulators for overhead lines is foolish. Insulators, since they are composed of a substance on the resistance of which (both electrical and mechanical) one cannot rely, have to be chosen with a very large factor of safety. As to the line construction, nowadays it can be done, by properly applied engineering, as safely as any other metal construction. Cases of wires breaking on well designed lines are very rare and due generally to lighting or to trees falling on the wires, or to other unforeseen reasons, to which we must now add also aeroplanes flying into the wires. Cables are also apt to give trouble, as a fault in manufacturing is sufficient to cause a break-down. But this is not a frequent occurrence.

The worst enemy of continuity of service is the atmospheric disturbance, especially for systems of medium tension. Very low-tension systems are easily protected and very high-tension systems are self-protected; the problem of complete protection is unsolved for line voltages ranging between 5,000 and 60,000 volts—I say unsolved in the sense that break-downs are not avoidable. Many of the protective devices used are effective for a single class of disturbances, but will not resist others, and, moreover, they are apt by their failure to increase the initial damage. Very much, however, can be done by strengthening all the elements of the systems, by using higher insulation, by spacing the bare live parts and by improving the quality of the machinery. In many plants the replacing of poor insulators with larger ones has done more than all kinds of protective devices.

This brings us to the consideration of the over-load and excess voltage protective devices. It may be generally said that for a system having only a single power house, the problem of protection is solved; a proper use of overload, differential and power return relays, and a well-studied graduation of the tripping currents and times can assure, to a very high degree of certainty, the exclusion of the faulty element before the whole system is affected. Two conditions are, however, necessary: all the relays of each class must be of the same type, or at least bear the same characteristics, and the adjusting for tripping current and time must be done under the strict control of a single department. If this is left to the chief electricians of power houses or substations the result will be confusion.

Things are not so easy when the system is fed by more than one power house. A point which is as yet unsolved is the easy control of the relay systems when energy has to be transmitted alternately in opposite directions in the same line. In such cases, however, the adoption of a well-organised service of load dispatching is absolutely necessary. And I may add that one of the most important actions to be performed is the quick restoration of service after an interruption. In a very complex system this can only be done by the dispatcher.

Interruptions and irregularities of service are a nuisance to the consumer.

But the producer also suffers by bad service, and this for three reasons:—(1) Every interruption, with very few exceptions, is accompanied by more or less important damage to some part of the installation. (2) During the interruptions the meters do not register. (3) An excess of interruptions produces by reaction a tendency for the most important customers to install their own generating plants. In addition, a poor regulation is generally accompanied by heavy energy losses in conductors.

Analysing these differing points, we may consider that, in a break-down of machinery and lines, or a break-down of insulation, repairs are the necessary consequence, and having to be done during the operation they are by no means economical. Take a line 50 miles long containing, say, 10,000 insulators, and suppose that the adoption of an insulator whose cost is 11*s.* instead of 10*s.*, would reduce by 1 per cent. per annum the number of punctured insulators, the first cost of the line would be increased by 500*l.*, and the annual charge for interest, sinking fund, &c., by, say, 75*l.* On the other hand, we have every year, 100 insulators less to replace. The practice of overhead lines shows that the cost of replacing an insulator averages 20*s.*, when the line is in operation; adding the cost of the insulator the total expense is 30*s.* There is a total of 75*l.* per year spent against 150*l.* per year which might be saved. This very simple example shows that the operating company, in giving better service, may also save money.

The same can be said about transformers and apparatus. As to interruptions, I would recall the case of a company operating a large hydro-electric system which distributes an average power of 50,000 kw. and in which the duration of the interruptions of supply amounts in a year to 15 hours. If we suppose the average selling price of the energy to be 1*d.* per unit, the loss due to meters not registering is more than 3,000*l.* per annum. This sum capitalised at 5 per cent. gives 60,000*l.* This means that the company could spend large sums in improvements and yet save money. As to the excess of voltage drop in conductors, it is nearly always a want of application of Kelvin's law in its simplest form. In the greatest number of cases of poor regulation, calculation will show that the saving of power wasted in the conductors would pay for the extra cost of additional copper.

In conclusion, we may say that a broad consideration of the combined interests of producers and consumers of electrical energy shows clearly the advisability of doing all in our power in order to reduce the interruptions and irregularities of service.

Service can be improved:—(1) By using machines, transformers, and apparatus of suitable size; (2) by treating the study and construction of lines as engineering problems, and by using very large insulators; (3) by adopting a rationally laid-out system of tripping relays and submitting to one control the adjustment of such relays; (4) by adopting a load dispatcher for large systems; (5) by reducing voltage drop in lines by a proper increase in the section of the conductors, and by improving regulation by the use of voltage regulators and synchronous condensers.

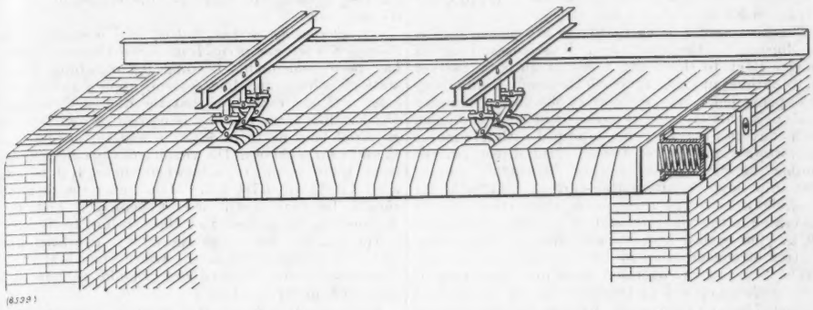
* Paper, abridged, contributed to Section G of the World Power Conference, on July 7, 1924.

THE BRISTOL "JUPITER" AERO ENGINE.—The Bristol Aeroplane Company, Limited, Filton House, Bristol, inform us that the 400 h.p. Bristol "Jupiter" aero engine, which we illustrated and described in our issue for April 25, has been tested by the Swedish Government to ascertain its suitability for employment under Arctic conditions. The tests were carried out some two months ago at Kiruna, which is within the Arctic circle, the engine being mounted on a Bristol fighter aeroplane, specially equipped with skis and tested both on the ground and in flight. We understand that the trials were successful in all cases and that, in one final test, the machine, which had been left in an open shed over night in a temperature of — 20 deg. C., was started up in the morning on the second swing of the propeller. The machine, shortly afterwards, was flown from Kiruna to Malmslaat, a distance of 1,300 kilometres (806 miles), in 6¼ hours, the pilot reporting on arrival that the engine had worked perfectly. The machine has since been purchased by the Swedish authorities, who had previously experienced much difficulty in operating aero engines under Arctic conditions.

THE INSTITUTION OF ENGINEERS (INDIA).—The fourth volume of the journal of the Institution of Engineers (India), published a short while ago, is a bulky issue containing a large number of folding lithographed plates, the reproduction of the latter being, however, hardly up to the style expected in such matters. It still seems difficult in India to produce a book which will compare well with European standards. As regards subject matter, which, after all, is the great thing, the volume contains much that is interesting in the form of a number of papers on a variety of subjects. Many of these are quite rightly of local interest, and will doubtless for this reason prove of greater value to members. Such papers include one on "Modern Indian Sewerage"; another is on the "Politics of Sub-soil Water." Others are "the New Indian Boiler Regulations" and "Working Costs in Small Power Plants." An investigation of the "Congestion of Calcutta" is made by Mr. T. A. F. Stone, of the North Western Railway. An account of the fourth annual general meeting held in February, 1924, is included in the volume, which, therefore, is very creditably up to date.

THE INSTITUTION OF ENGINEERS, AUSTRALIA.—The second volume of the Transactions of the Institution of Engineers, Australia, has recently been published, and contains an interesting record of the proceedings of this institution for the year 1921. While members will be glad to have on record the statement of the affairs of their body, the delay in publication robs this part of the volume of much of its interest. The major portion of the issue is, however, devoted to a dozen or more papers read before various centres and many of these are of much more permanent value. The address on the development of the institution, by the then president, Mr. W. J. Newbigin, is also of considerable interest, dealing with the attitude of engineers in that country towards politics. The papers published include one by Mr. J. S. Dethridge on "Irrigation Works and Practice in Victoria." Mr. Dethridge, being a member of the State Rivers and Water Supply Commission of the State of Victoria, is well qualified to speak on this subject. Of other papers were such subjects as corrosion in condensers, rainfall intensities, concrete footings for columns, impact losses of jets, &c.

THE PLUTO SUSPENDED FURNACE ARCH.



(6338)

THE PLUTO SUSPENDED FURNACE ARCH.

THE increasing width of boiler furnaces, whether fired by mechanical stokers or pulverised fuel, has necessitated considerable changes in the design of the arches over them, for the rise of ordinary spring arches becomes inconveniently great for modern furnace widths. Since the function of an arch is merely to provide a refractory roof to the furnace, there is no need for the usual curved form which has been adopted for structural reasons and indeed a roof horizontal from side to side, and therefore having no rise at all, would be generally preferable. A furnace roof of this kind is, of course, not an arch at all, but the construction has become known under the name of a "suspended arch," which indicates its nature sufficiently well. The brickwork of a suspended arch is hung from transverse steel girders protected from the heat. Although the arch is horizontal from side to side, it may be made of almost any shape desired from back to front, being flat, stepped, tapered or curved in a longitudinal direction according to the ideas of the designer as to which is best for the particular circumstances.

There are several types of suspended arch construction now in use, varying both in the nature of the steelwork and the form of the bricks used in them. Many of these have the disadvantage of being very heavy and expensive on account of the large amount of steelwork they involve. The Pluto Stoker Company, of 2, Upper Westbourne-terrace, London, W.2, have developed a design of comparatively light and therefore inexpensive construction, the nature of which will be understood from the illustration above. It will be noted that the bricks are able to expand in all directions without introducing appreciable stresses, this being an important point in connection with furnace work. The steelwork, moreover, is reduced to a minimum, only one brick out of every eight or ten being directly suspended, instead of nearly every other brick as in some types of arch. Indeed, the Pluto Stoker Company claim that with a furnace of less than 6 ft. 6 in. wide it is not necessary to have any suspension at all. From 6 ft. 6 in. to 12 ft. wide one brick in every row is suspended; from 12 ft. to 19 ft. two bricks in every row; and from 19 ft. to 25 ft. three bricks in every row.

In the side walls are two cast-iron boxes containing a number of springs, the compression of which can be regulated by bolts on the outside. The springs act on side plates which press against the bricks of the arch, and the arch can expand as its temperature rises with no restraint other than that of the springs. The arch bricks are of a very simple form, a few shapes only being required. The shape of the bricks is such that all the joints are perpendicular to the surface which is exposed to the flames, as it has been found in practice that vertical joints are more resistant to furnace conditions than inclined joints. The erection of the suspended arch is carried out on a timber platform of simple construction, which provides the necessary support until the bricks are in place.

LOADLINES OF JAPANESE SHIPS.—**The Board of Trade has certified that certain statutory regulations, which have been approved by the Japanese Government relating to overloading, so far as regards the assignment of loadlines to Japanese ships, are equally effective with the corresponding regulations in force in this country respecting the assignment of loadlines to British merchant ships. An Order in Council, dated March 21, has therefore been made, directing that, on proof that Japanese ships have complied with the aforesaid Japanese Regulations, such ships shall not, when in ports of the United Kingdom, be liable to detention for non-compliance with the provisions of the Merchant Shipping Acts relating to overloading, nor shall there arise any liability to any fine or penalty which would otherwise arise for non-compliance with those provisions.**

CATALOGUES.

Electric Welding.—A catalogue of electric welding machines for spot, seam and butt joints has come to hand from Messrs. Perkin and Co., Limited, Leeds.

Shears.—A catalogue of scrap shears, open-ended bar and plate shears, billet shears with automatic feed rollers, and splitting and guillotine shears has been issued by Mr. Henry Pels, 40, Great Marlborough-street, London, W.1.

Switchboards.—All-steel, draw-out, truck-type switchboards, as designed and manufactured by Messrs. Johnson and Phillips, Limited, at their works at Charlton, London, S.E.7, are dealt with in an excellently prepared catalogue to hand from that firm.

Woodworking Machines.—Messrs. H. G. L. Young, Limited, Upper Hollingdean-road, Brighton, have sent us a priced catalogue of small power-driven woodworking machines, including a saw bench, band saw, several planers, a spindle moulder and a mortising machine.

Railway Wagons.—The Cambrian Wagon Company, Limited, Cardiff, have sent us a copy of the second edition of a catalogue containing full specifications of their standard and tipping wagons, as well as lists of firms for whom wagons have been built and of stations at which repairs can be carried out.

Marine Electrical Machinery.—A catalogue of generating units, motors, switchboards, winches, windlasses and fans for use on board ship, is to hand from the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester, who supply complete marine electrical equipment for lighting and auxiliary power.

Wind Mill.—The Lambert Engineering Company, Harrow, Middlesex, have issued a new edition of their catalogue of wind-driven generating plant for electric lighting, in which the dynamo is mounted on the top of the mast. All the details are explained, and advice is offered to possible users of the plant in any situation.

Machine Tools.—Messrs. Brown and Ward, Limited, 27, Great Hampton-street, Birmingham, have sent us a catalogue of machine tools, showing a series of capstan and centre lathes, automatic turning machines, milling, drilling and shaping machines, &c. The tools are illustrated and dimension and capacity tables are given.

Lubrication.—A catalogue and several leaf circulars to hand from Tecalemit, Limited, 10, Little Portland-street, London, W.1, contain descriptive matter of the firm's grease gun, grease cups, connecters and other fittings for forcing grease into bearings. The appliances are suitable for motor vehicles as well as for general industrial use.

Insulating Materials.—A well-arranged catalogue, with excellent explanatory matter, of insulating materials and finished parts made of mica, paper, presspahn, asbestos cloth, natural resins and synthetic resins, has come to hand from Micafil, Limited, through their agents, Impag, Limited, 88, Fenchurch-street, London E.C.3.

Tools.—A great variety of hand-tools, vices, jacks, cramps and accessories for lathes and drilling machines are illustrated, with tables of dimensions and prices, in the 1924 edition of their catalogue issued by the Steel Nut and Joseph Hampton, Limited, Wednesbury. The company manufacture all the tools and appliances referred to in the catalogue.

Line-Shaft Bearings.—The Hoffman Manufacturing Company, Limited, Chelmsford, Essex, have issued a new catalogue of a ball and roller bearings for line shafting. Particulars are given of complete countershafts and of various brackets, hangers, girder clips and other fittings required for shafting, as well as of a type of bearing lighter and less costly than the standard pattern.

Locomobile Engines.—A new issue of their catalogue of locomobile engines, which constitute independent power units having compound engines mounted on a horizontal boiler, is to hand from Messrs. Marshall, Sons and Co., Limited, Gainsborough. The list gives particulars of eight sizes ranging from 50 h.p. to 250 h.p. for normal running. The engines, however, will carry a continuous overload of about 25 per cent. and a momentary overload of about 40 per cent. The whole unit can be placed on any good foundation, without attachment to the building, and is readily removable.

BACHO ADJUSTABLE WRENCH.

THE wrench, of which we give an illustration in the annexed figure, is one of three patterns recently placed on the market by Messrs. Buck and Hickman, Limited, 2-6, Whitechapel-road, E.1. These wrenches are of Swedish manufacture by Messrs. B. A. Hjorth and Co., of Stockholm, and are fully up to the standard of quality with which the name of "Bacho" is associated. The wrench illustrated is made of two main parts, drop-forged. It is free from projections and can be employed in awkward places into which an ordinary wrench could not be inserted. The method of gripping combines simplicity with robustness, one limb having arc indentations stamped upon it, while on the enveloping piece are corresponding stamped projections, engaging with the teeth of the other part. The arcs are struck in such a way that fine adjustment and a very good grip are obtainable, and the wrench

promises excellent service. It is made in sizes for grips from 1¼ in. up to 3 in. The end of one limb is finished to serve as a screwdriver.

Another wrench by the same makers is one of the Clyburn type, in which the jaw opening has been made rather larger than usual, and set at 15 deg., so that, by reversing, a nut in practically any position can be gripped. Although the thickness of the head has been made narrow, so that the spanner may be used for close-quarter work on automobiles, &c., care has been taken to provide good support for the movable jaw and a good backing of metal at the heels. This spanner is a double-ended tool, having at the handle end a crocodile pipe wrench. The third spanner of the same series which Messrs. Buck and Hickman are now introducing, is a single-handle pipe wrench in which the parts have been made as simple and reliable as possible. The usual flat springs pressing on the adjustable jaw shank, which are so liable to get broken, have been replaced by a single helical spring. This should undoubtedly prove an advantage. This wrench, like the others, is an excellently finished article. It is made in lengths of 10 in., 14 in. and 18 in. for pipes of from 1¼ in. to 2½ in.

INFLUENCE OF TITANIUM ON IRON CASTINGS.—Experiments conducted by E. Piwowarsky, of the Technical High School, Aachen, confirm previous statements as to the improvement of cast iron by small additions of titanium. The new experiments (*Stahl und Eisen*, June 26) were purposely made with a high-carbon pig containing 3·38 per cent. of carbon, 0·49 per cent. of silicon, 0·45 per cent. of manganese and 1·15 per cent. of sulphur. The pig was remelted in an electric Tammann furnace of graphite lined with magnesite, the ferro-titanium being added to the fused metal in lumps, which were pushed under by means of carbon rods provided with cup-shaped ends, the cups being lined with magnesia. Less than half of the titanium added (0·8 per cent. maximum) was taken up by the iron, which showed a much finer grain than before. Test rods were then taken from this iron and heated to 1000 deg. C. for many hours (10 to 50). The grain was made still finer, and it was found that the titanium hastened the decomposition of the iron carbide and the gasification of the carbon. There were marked increases in tensile strength and elongation.

TRANSMISSION OF ELECTRIC POWER FROM NORWAY TO DENMARK.*

By A. R. ANGELO, Nordsjaellands Electricitet and Sporoejs A/S., and WM. RUNG, Professor of Electrical Engineering, Engineering College, Copenhagen.

In the year 1921 three commissions were appointed, one by the Danish, one by the Norwegian, and one by the Swedish State, with the object of investigating the question of transmission of electric power from Norway to Denmark. These commissions elected from among their members a Joint Committee consisting of six engineers, two from each country, for the investigation of the technical and financial aspects of the matter. In 1923 this committee put forward a report, the main points of which are given below :—

It appears that the total power consumption which can be anticipated in Denmark when (presumably in the course of 10–15 years) all lighting and power both in the towns and in the country (railways excepted), has been electrified, will amount to about 500,000,000 kw.-hours per annum with the common maximum of about 157,000 kw. corresponding to about 3,200 hours. On account of this comparatively small number of hours it will not pay to build transmission lines for the whole of this energy. However, it might possibly be of advantage to take delivery of part of it this way, corresponding to about 6,500 hours. This energy would amount to about 63,000 kw.

If transmission of power from Norway were to begin before the expiration of the above-mentioned 10–15 years, it would be most correct, to begin with, about 42,000 kw. The various plans worked out are all based on this latter assumption.

The investigations show that there are two routes along which the electric power from Norway might be transmitted to Denmark, viz.,—(1) By means of submarine cables under Skager Rack to Jutland, and from there on to Fyen and Sealand. (2) By means of high-tension lines overland through Sweden, crossing Oresund (The Sound) either by means of submarine cables or by means of aerial lines to Sealand, and from there on to Fyen and Jutland.

In the following are given some comments on these various suggestions :—

With regard to the first the depth of Skager Rack is very great, as much as 600 m., and the distance across is also very great, about 130 km., and the sea is usually rough. For these reasons no kind of cable other than the one-core type can be used, because only this kind can be supplied in one-length and thus be laid without splices from coast to coast. The cables might be used for transmitting either alternating current or direct current, but considering the number of crossing or parallel cables it would not be advisable to use anything but direct current.

With regard to the second route experience has shown that a submarine cable across Oresund can be made as a single core or triple core cable. Similar cables can also be laid across the various "belts" and "sounds" within Denmark, so that it would be possible to use either direct current or alternating current. Furthermore, it would be possible to cross Oresund by means of aerial lines north of Elsinore whereby submarine cables could be avoided except between Sealand, Funen and Jutland.

Thus there are the following four separate alternatives for the carrying out of the power transmission :—(*a*) direct current system with submarine cable across Skager Rack ; (*b*) direct current system with overhead lines overland through Sweden and submarine cable across Oresund ; (*c*) alternating current system with overhead lines overland through Sweden and cable across Oresund ; (*d*) alternating current system with overhead lines overland through Sweden and aerial lines across Oresund.

(*a*) *Direct-Current System with Cable across Skager Rack.*—Hitherto no very extensive use has been made of the Thury direct current series system of transmission.

Considering, however, the latest improvements which permit both higher tension and higher current (7,500 volts per commutator and 250 amp.), it might in the present case be possible to use this system to advantage, as it is a question only of transmitting power from one point in Norway to two or three main distribution centres in Denmark. The relative working pressure between the conductors in this system can, according to previous experience, be taken to be 110 kv. between conductor and earth, or 220 kv. between the individual conductors. It is planned to build the power station in Southern Norway a distance about 80 km. from the coast, where ample water power is available. The power station should be equipped with water turbines, each developing about 10,000 h.p. and each one direct coupled to a generator system consisting of two direct current double generators (series-generators) coupled together, each designed for 7,000 volts × 250 amp. = 1,750 kw. Thus each group will supply 28,000 volts × 250 amp. = 7,000 kw. With eight turbines working, the station would thus be able to supply a maximum of 224,000 volts at a current of 250 amp., or, in other words, 56,000 kw.

The lines would be carried from the power station in Norway to the coast near Kristianssand across Skager Rack to the North Coast of Jutland, further on to Aarhus, and from there *via* Sams and Kalundborg to Copenhagen, a total distance of 565 km. Converter stations should be built at Aarhus and in Copenhagen, each converter station being equipped with five motor converters consisting of two coupled direct current double motors (series motors) 6—7,000 volts × 250 amp. and an alternating-current generator for 6—7,000 kv.-a. The three-phase alternating current generated in the converter station is transformed up to 50 kv. (50 cycles) and is distributed to the various centres of consumption in Denmark at this voltage.

The 2 × 110 kv. overland lines for direct current both in Norway and in Denmark should be built as overhead lines on steel masts with suspension insulators, whereas the submarine cables across Skager Rack, the Belts, and Cattegat, should be made as iron-wire-armoured single core cables with impregnated paper insulation. For the complete system three conductors should be used everywhere, so that one spare line is always available besides the earth. During operation the spare line should always be connected in parallel with one of the two other lines. The centre of the system should be connected to earth both at the power station and at the farthest converter station, so that the whole forms a three-wire system with the earth as zero. The 50 kv. alternating current lines distributing from the converter stations in Denmark should be carried on steel poles with suspension insulators.

By means of the above system 42,000 kw. out of the 56,000 kw. (measured as three-phase alternating current at 50 kv.) generated in Norway can be transmitted to the centres in Denmark. Thus the efficiency of the system is about 75 per cent.

(*b*) *Direct-current system with overhead lines through Sweden and submarine cable across Oresund.*—What has been said above under heading (*a*) regarding the working, voltage, transmission lines, power station and converter stations for the direct-current system, also applies to this alternative. The power station in Norway should be placed at the Nore Falls or some other place not further off from Denmark.

The 2 × 110 kv. direct-current lines should be run from the power station crossing the Norwegian frontier at Kornsjo, following the Swedish west coast, crossing Oresund near Elsinore, then on to Copenhagen, and from Copenhagen via Korsor, Nyborg and Kolding to Aarhus, a total distance of 985 km. Converter stations should be built at Copenhagen, Kolding and Aarhus. This system could transmit 42,000 kw. (measured as three-phase alternating current at 50 kv.) out of the 56,000 kw. generated in Norway. Thus the efficiency would be 75 per cent.

This system as well as the alternating-current system described below under heading (*d*) could be built with aerial lines across Oresund instead of submarine cable. However, as cables can be built for a tension as high as that contemplated for the aerial lines (2 × 110 kv.), the latter would present no particular advantage.

(*c*) *Alternating-current system with overhead lines through Sweden and cable across Oresund.*—For this three-phase alternating current should be generated at the Nore Falls or some other station not further from Denmark. The pressure should be stepped up to 132 kv. (50 cycles). It would thus be possible to connect up direct to such systems as Trollhättan, which might be of importance in case of repairs.

The lines should be run as overhead lines crossing the Swedish-Norwegian frontier at Kornsjo, further on through Sweden to a main transformer station at Helsingborg, a total distance of 110 km. This transformer station should be equipped with transformers for 132–50 kv. and with synchronous motors and possibly reactance coils for regulating the pressure under varying loads.

In this station the pressure would be stepped down to 50 kv., the highest alternating-current pressure suitable for submarine cables. From Helsingborg the electricity is distributed to the various centres in Denmark through four three-phase 50 kv. lines, viz., two to Sealand and two to Funen and Jutland.

The 132 kv. lines from Norway to Helsingborg should be made as one double three-phase overhead line on steel masts with suspension insulators.

The 50 kv. lines in Denmark should be made as overhead lines on steel poles with suspension insulators, whereas the submarine cables should be made as steel-wire-armoured three-core cables with impregnated paper insulation.

For regulating the voltage it would be necessary to make rather extensive use of synchronous motors at the various main centres in Denmark.

This system will be capable of transmitting 42,000 kw. to the centres in Denmark with an efficiency of 73 per cent. The energy transmitted could be increased up to say, 53,000 kw., which figure represents the limit for this system. In this case the efficiency will be 65 per cent.

(*d*) *Alternating-current system with overhead lines through Sweden and aerial lines across Oresund.*—What has been said under heading (*c*) regarding power station, voltage and line system, applies also to this case, with the exception that the double three-phase 132 kv. line from Norway is carried across Oresund as aerial lines north of Elsinore and further on from there to somewhere in the vicinity of Copenhagen, and from there again to somewhere near Kalundborg, a total distance of 760 km. Main transformer stations should be built both near Copenhagen and near Kalundborg for reducing of the pressure to 50 kv. ,

The 132 kv. lines, also the 50 kv. overhead lines and cables running from the transformer stations at Copenhagen and Kalundborg, should be made as described under heading (*c*).

Synchronous motors and possibly also reactance coils would be necessary for regulating the pressure, not only at the main transformer stations, but also elsewhere in the system.

The aerial lines across The Sound should be carried by two structural steel towers, having a height of about 200 m. above sea level and built in The Sound, and further supported by a somewhat lower structural steel tower on the Danish coast. There would be two spans each of 2,300 m. and a shorter one (about 1,100 m.) on the Swedish side. The lines should be made of a core of twisted steel wire with a sectional area of 240 sq. mm. and with a covering layer of aluminium wires having a section of 110 sq. mm. It will be safe enough to keep these lines so taut as to give, under all circumstances, a clearance of 60 m. above water level.

With a pressure of 132 kv. this system could transmit 42,000 kw. to the centres in Denmark with an efficiency of 74 per cent. If the pressure in the main lines were increased from 132/220 kv., and if the whole 50 kv. line system in Denmark were doubled, an energy of 105,000 kw. could be transmitted with an efficiency of 79 per cent.

First cost and possibilities of financial success.—Assuming that the electricity can be sold by the power station in Norway at a price of 80 Danish kroner per kw. annum, the first cost, the selling price of current delivered at the distribution centres in Denmark, and the efficiency of the system as a whole for the four different alternatives (*a*), (*b*), (*c*) and (*d*) will be as follows :—

Transmission of 42,000 *kw.*

	First Cost. Mill kroner.	Price per kw. annum. Kroner.	Efficiency. Per cent.
(*a*)	49·6	224	76
(*b*)	56·4	240	75
(*c*)	57·9	251	71
(*d*)	60·6	244	80

Transmission of 105–109,000 *kw.*

	First Cost. Mill. Kroner.	Price per kw. annum. Kroner.	Efficiency. Per cent.
(*a*)	84·2	180	78
(*b*)	92·8	188	78
(*c*)	—	—	—
(*d*)	83·5	181	79

It appears from the above that with a transmission of 42,000 kw. and consuming time of 6,500 hours the price per kw.-hour will be from 3½ to 4 ore.

The Committee has not expressed any opinion as to which one of the four alternatives is to be preferred, but has pointed out that on account of the difficulties to be expected from a submarine cable across Skager Rack, alternative (*a*) is not to be recommended until more far-reaching investigations have been carried out.

* Paper, abridged, contributed to Section G of the World Power Conference, on July 7, 1924.

THE "BRISTOL BLOODHOUND" MILITARY AEROPLANE.—A new two-seater military biplane for reconnaissance work or fighting and known as the "Bristol Bloodhound," has recently been constructed by the Bristol Aeroplane Company, Limited, Filton House, Bristol. No particulars of the dimensions or performance of the machine are at present available, but we may mention that the structure is built entirely of metal, while standard fabric is used for covering the wings, fuselage and tail unit. The machine is fitted with one of the Bristol "Jupiter" 400 h.p. air-cooled radial engines, as illustrated and described in our issue of April 25 last on page 551, and tanks are provided for 104 gallons of petrol and 15 gallons of lubricating oil. All the control surfaces are balanced so that the machine is particularly light and powerful on her controls ; complete dual control is provided. The armament includes two Vickers' machine guns operated by the pilot, and a Lewis gun operated by the gunner, while fittings are installed for carrying bombs. The wings are arranged with a large stagger and considerable sweepback so that both pilot and gunner have a wide field of vision—a feature which is obviously of considerable importance for the class of work for which the machine is intended.